Electricity Up to Date

For Light, Power, and Traction.

BY JOHN. B. VER

F. WARNE & CO.

LONDON AND NEW YORK.

LIVERPOOL OVERHEAD RAILWAY CAR.

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PREFACE

TO THE FOURTH EDITION.

AS some 15,000 copies of this little work have now found their way into circulation, the Author has reason to hope that it meets the demand for a popular book on a subject of increasing general interest.

In the present Edition the work has once more been considerably enlarged, and many illustrations have been added, while, to justify its title, the contents have again been thoroughly revised.

Since the chapter on Electro-therapeutics was added last year attention has been called in a public manner to the extravagant nature of the virtues claimed for Electropathic Belts. Still, the value of Electricity in the treatment of disease cannot be over-estimated, but it must be at the hands of only duly qualified medical scientists.

Electricity has already done much to alter the whole condition of our daily life, and in the new chapter on Electric Cooking and Heating it will be seen how admirably it lends itself to improved methods of cooking our food and warming our houses.

J. B. V.

31 KING STREET,
COVENT GARDEN, LONDON,
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and accepts the most complex of natural phenomena as simple and obvious facts.

Thales of Miletus (B.C. 600), one of the seven Sages of Greece, is the first who refers in his writings to the power amber possesses, when rubbed, of attracting small bodies. It is thus from the Greek word, *elektron amber*, that the word Electricity has been derived. Without further evidence, it must be assumed that the knowledge of the Ancients was confined to the fact that amber, when rubbed with silk or other soft material, becomes capable of attracting small particles of pith or any light non-conducting substances.

History does not record any further knowledge of the science until about the year 1590, when Dr. Gilbert, whose position as private physician to Queen Elizabeth gained him the favour and means of carrying out his scientific experiments, made a series of further discoveries. He found that glass, sulphur, and other bodies as well as amber could be Electrified by friction, that the production of Electricity was effected by moisture, and that heated bodies lost all Electricity.

Little advance was made during the next hundred and fifty years, until a French scientist, Du Fay, found that Electricity was of two different kinds. His investigations showed that the Electrical effect produced by rubbing glass, which he termed *vitreous* Electricity, *repelled* a pith ball which was *attracted* by the Electrical effect of rubbing resin or amber, and which he termed *resinous* Electricity. The common terms of Electrical science have since grown up from these older theories, *vitreous* and *resinous* being now known as *positive* and *negative* Electricity.

These ideas later found further support by the discovery that dust, as shown in the illustration, assumed different shapes when shaken out from a muslin bag over surfaces positively or negatively charged by Electricity.

The interest thus awakened in Electrical phenomena also caused more attention to be given to apparatus for conveniently rubbing glass, sulphur, and other such bodies until the Frictional Machine enabled Electrical effects to be produced on a larger scale. Since that time it has been found that Electricity may be obtained in other ways, and the science has been so far developed that Electricity is now as completely under man's control as

POSITIVE DUST FIGURE.

NEGATIVE DUST FIGURE.

steam, while its action may be governed and its results predicted with an equal degree of accuracy.

The nature of Electricity in all its innumerable aspects has still to be investigated. What is Electricity? may be termed *the* question of the physical world at the present time, and its determination will long continue to be of absorbing interest to all great scientists.

In that fascinating work, "Modern Views of Electricity," Professor Oliver Lodge expounds the doctrine of the ethereal nature of Electricity as it is now understood by the leading thinkers. He divides the whole subject of Electricity into four great branches:—

1. Electricity at rest, or Static Electricity. This

embraces all the phenomena capable of being set up in insulating, or what are often called non-conducting, bodies by the neighbourhood of Electric charges.

2. Electricity in locomotion, or Current Electricity, which includes the modes of setting Electricity in motion, or what is generally termed producing Electricity, the laws of its flow and the effects produced by its passage through conductors.

3. Electricity in rotation, or Magnetism, which treats of the phenomena belonging to Electricity in whirling or vortex motion and the various properties of what is usually termed Magnetism; and

4. Electricity in vibration, or Radiation, wherein is shown the identity of Electrical vibrations with light and colour and the multitude of phenomena studied for a long time under the heading of "Light."

These pages will only be concerned with the second of these four great divisions, *Electricity in locomotion, or Current Electricity*, and as such it may best be defined as a form of Energy. By the word Energy is understood the power of doing work—no matter by what means the work may be done; and just as heat, mechanical power, chemical action, &c., are forms of energy, so is Current Electricity.

It has been pointed out that Electricity is not some recently discovered *addition* to man's power of doing work in the world, but another mode of utilising energy that already exists, and a mode which in many instances presents distinct advantages over the use of other forms.

When energy in any one form seems to disappear, it is really only changed into some other form. Thus, when the ancient philosophers rubbed pieces of amber and silk together, they simply expended potential energy of the

body, and which reappeared in the form of Electric Energy. The foundation of this principle, known as "The Conservation of Energy," one of the grandest of known physical laws, was laid down by Newton, and it was afterwards shown by Joule that the disappearance of a given amount of one kind of energy always gives rise to the appearance of a *perfectly definite* amount of energy in another form.

To obtain Electricity, therefore, energy in some other form must be expended, whether it be the energy of chemical combustion as in a battery, or the potential energy of coal used in the mechanical working of dynamo machines.

There may be said to be four methods of obtaining or exciting a flow of Electricity—in other words, of producing it:—

1. By friction, as in the Frictional Machine.
2. By chemical action, as in Primary Batteries.
3. By heat, as in the Thermo-Pile.
4. By magnetic induction, as in the Dynamo.

Atmospheric Electricity, so well known in the form of lightning, is produced by one or more of the above-named means, some attributing it to chemical action and heat, others to the friction of clouds passing over one another. But although Franklin, with his experimental kite, was able to obtain Electricity from the clouds, its causation is not so readily determinable.

Assuming, therefore, that Electricity for present purposes must be generated by one or other of the four methods mentioned, it is desirable to carefully consider each one separately.

By Friction.

The Frictional Machine.

Electricity is produced from the frictional machine by expending energy in the form of mechanical power, and, as already pointed out, this method is the outcome of the discovery made by the ancient Greeks.

At first the Electrical effects were obtained by rubbing the various substances with the hand, but the result thus produced was very small indeed. The earliest form of frictional machine was a sulphur ball, which could be spun on an axle, but in later forms of apparatus a glass plate was employed, with rubbers held in position by springs. On revolving this machine the glass became positively charged, while an equal quantity of negative Electricity is produced on the rubbers.

Electricity can be collected off these frictional machines so long as the glass plate is rotated, and many interesting experiments are performed with them. The modifications that such apparatus have more recently undergone, as well as descriptions of the Leyden Jar for collecting charges of Electricity, the Electrophorous, &c., are to be found in all students' manuals of Electricity.

The frictional method of producing Electricity, however, will never be of much service. The current that can be obtained is but small, while the moisture of the air often causes experiments with them to fail.

By Chemical Action.

Primary Batteries.

It was towards the close of the last century that Galvani and Volta made their important experiments, which resulted in Electricity being produced by chemical means. Hence, currents excited in this way are often called Voltaic or Galvanic Electricity.

The convulsive contraction of a frog's leg when accidentally in contact with a frictional machine was first noticed by Dr. Galvani, a celebrated anatomist of Bologna. As the apparatus was not in use, he was led by his investigations to the view (published in his "Researches," 1791) that the effects were due to Animal Electricity. In the following year Volta, a professor of natural philosophy at Pavia, opposed this idea, and laid down the opposite theory, that the effects were rather caused by some Electric force produced through contact with the metals themselves. Poverty and ill-health prevented Galvani from following up his discoveries, but Volta, after a long series of experiments, was able to obtain Electricity by means of chemical action between metals, and finally he invented the Voltaic Pile. This apparatus, which he described in a communication to the Royal Institution in 1800, consists of metal discs of zinc and copper immersed in acidulated water. On connecting the metals externally by a wire, Electric currents can be obtained, and in its various modifications, this is what is now known as a Primary Battery.

Since the time of Volta innumerable batteries have been invented, as their construction is capable of almost indefinite variation. In the first place, any combination of two different metals may (theoretically) be used; then, again, the solution in which they are immersed may consist of almost any acid or salt; nor are we confined to one chemical, for in many batteries there are practically two solutions totally distinct in character, one being separated from the other by a porous partition. With restrictions so undefined, and so extensive a scope for variation, it is by no means surprising that numbers of different types of batteries exist.

For telegraph work, telephones, electric bells, &c.,

where the pressure and quantity of Electricity required is but small, primary batteries will always be most serviceable. But for Electric lighting or any purpose for which a large amount of Electric Energy is required, it is impossible for any primary battery, no matter how efficient for small work, to be used with any degree of success. The idea is, however, so fascinating (especially for company promotion) of obtaining even a few Electric lights for a country house by means of chemicals, that new primary batteries are continually making their appearance. Even in our most important journals wonderful accounts have been published from time to time of some new combination at last triumphing over all difficulties, and public belief in them is artificially maintained in this way.

As many are thus induced to believe that important discoveries may be going on behind the scenes, it is desirable to point out a few of the many reasons why primary batteries, although useful for some purposes, are not serviceable for Electric lighting.

In the first place, chemical action necessarily implies a using up of the elements in the battery, and as this takes place the currents given off become gradually weaker. Where the currents required are small or are only used occasionally this causes little inconvenience, but when the chemical action is a rapid and continuous one, the effect is soon noticeable. Now, it is essential for Electric lighting that an even flow of Electricity should be maintained, otherwise the incandescent lamps at first glowing brightly will gradually become dim, until at last nothing remains of the light but a dull, red glow.

Again, a single cell produces such a very small pressure of Electricity that a large number of them would be *required to supply* even a few Electric lamps, and to keep

so many cells in good order and properly charged with the requisite chemicals, constant and careful attention would be needed.

Finally, it is as well to point out that the Energy acquired from all primary batteries, no matter of what type, must necessarily be obtained by the destruction of some element, usually zinc. As Electricity is generated the zinc is consumed, and has to be continually renewed. The cost of fresh supplies of zinc would be very great for a large number of batteries, where, as for Electric lighting, the chemical action is a rapid one. The price of a pound of zinc is twenty times as much as the price of a pound of coal, and if the full equivalent in the form of energy could be obtained from each, coal would yield six times as great a result.

From the foregoing it will be seen that the primary battery can only be effectively employed when small or intermittent currents of Electricity are used. Although admirably suited for working telegraph instruments, electric bells, telephones, &c., some other means must be sought for economically and conveniently generating Electricity on a larger scale, suitable for lighting and power purposes.

By Heat—Thermal.

The Thermo-Pile.

The possibility of producing Electricity by the direct application of heat was first demonstrated by Seebeck, in Berlin, in 1821. The apparatus thus formed is termed a Thermo-Pile. From the fact that the pressure of the current is proportional to the difference of temperature of the heated metals, the Thermo-Pile becomes of great service for measuring all minute differences of temperature. Thermo-

Piles, however, as at present constructed, easily get out of order and break down, while as yet no thermal combination is practicable by which Electric currents can be produced on a scale large enough for light or power.

To produce Thermal Electric currents, the ends of two strips of different metals are connected or soldered together, and heated where they join. When their free ends are connected by a wire, Electric currents will continue to pass through the wire as long as the heat is maintained. Electricity can thus be produced by the combination of many substances; bismuth and antimony give the best results, but owing to their cost, iron and German silver are more commonly employed.

Although much has been learned of the principles underlying these Thermo Electric phenomena, very little other progress has been made, as there are many difficulties in the way of producing currents of any magnitude by them. The subject has the earnest attention of Mr. Edison and other eminent scientists, and it is generally considered that sooner or later a great development of Thermal Electricity will take place. It is conceivable that by its means a method might be devised for producing Electricity on a small scale far cheaper than is obtainable from small dynamos. Electricity produced by the dynamo—at present the most economical mode—is at the expense of a double conversion of Energy, for though it is directly obtained at the expense of the mechanical power which the steam-engine exerts on the dynamo, that mechanical power was originally obtained from heat applied to the boiler. So that if Electricity can be produced from heat applied direct, the services of the middle agent—mechanical power—will be dispensed with, and an economy effected.

By Induction.

The Dynamo.

The dynamo is the source with which Electricity has been principally associated of late years, and if ever it be superseded it can only be by an advance in our knowledge entitled to rank as a great scientific discovery.

The currents produced by its means are scientifically known as Inductional Electricity, since they are magnetically induced. But as the dynamo affords the most economical means of producing Electricity for light, power, or traction, and will probably long continue to do so, it is proposed to reserve a separate chapter to its description and method of working.

CHAPTER II.

THE DYNAMO, AND HOW IT IS DRIVEN.

WHILE experimenting with a primary battery current in 1831, Faraday discovered the close relationship of Electricity and Magnetism—a discovery which led to the invention of the dynamo. He showed as the result of his experimenting, that when a coil of insulated wire is revolved between the poles of a magnet, Electric currents are excited or "induced" in the coil of wire.

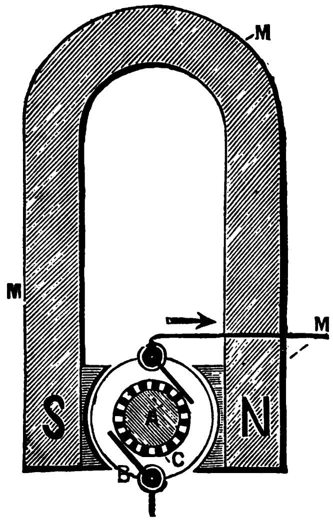
A dynamo is merely a machine in which such a coil of wire, termed an armature, is revolved by mechanical means, between the poles of one or more magnets.

Magneto-Electric Machines.

After Faraday had found by his experiments that Electricity could be obtained from magnets, it was not long before the construction of a new form of electric generator was attempted. Pixii of Paris in 1832 first succeeded in doing this practically, and historic interest attaches to his machine, as, although rough and imperfect, it carried out the essential principle of the discovery. The apparatus was termed a Magneto-Electric Machine, and was the forerunner of many similar devices.

In all such Magneto-Electric Machines the electric currents were developed in the armature by means of magnetism provided by permanent steel magnets, and the accompanying diagram shows an armature, A, between the north and south poles of such a magnet, M, M.

In these early efforts there was no attempt to make the machine excite its own magnetism, and it was not until some years after, that the use of *electro-magnets* in place of permanent magnets paved the way for the suggestion of the present self-exciting dynamo.



Dynamo Electric Machines.

In the dynamo the magnet employed is not the ordinary horse-shoe or *permanent* steel *magnet*, but an *electro-magnet*. This is formed by sending an Electric current through a coil of insulated wire encircling a piece of ordinary soft iron, which is thus rendered temporarily magnetic. Such a magnet has similar properties to the ordinary steel magnet, but its magnetism, although not permanent, can be rendered more intense. On account of this and other specific advantages, it is always now used in preference to a permanent magnet, and machines so made are termed Dynamos.

At first, as in the combined machine constructed by Wilde in 1867, a small magneto-electric machine was constructed to supply Electricity for the electro-magnets of the larger machines. Further experimental work, however, showed that the electro-magnets could be made to magnetise themselves, and the dynamo thus made self-exciting. The method by which this result is obtained can best be understood by explaining the action of the machine more fully.

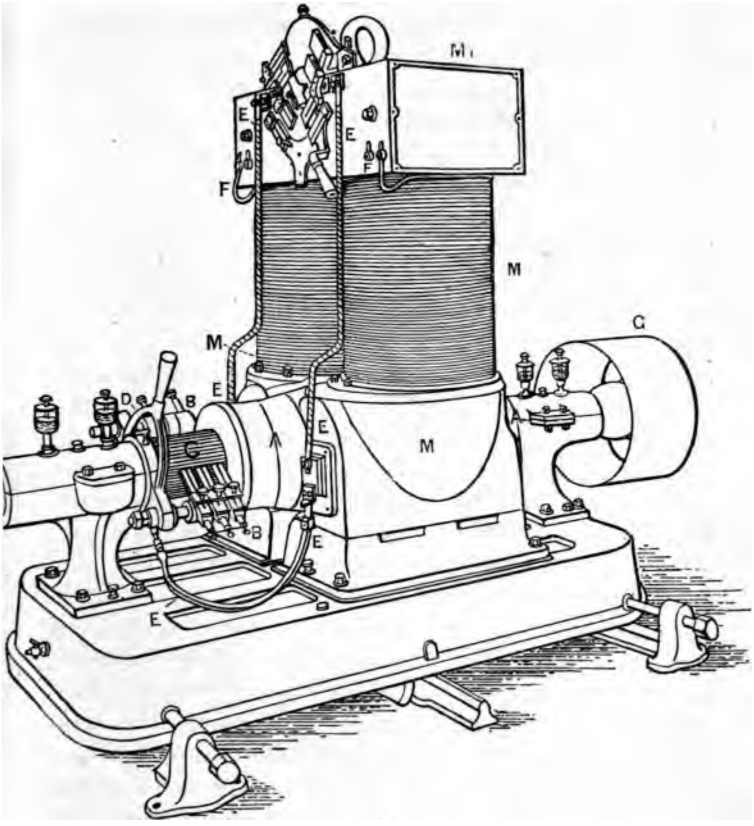
When the armature revolves between the two poles of the electro-magnet, Electricity becomes magnetically induced in the wires forming the armature. Until this is revolved no Electric current is produced, but immediately it is put in motion the slight amount of residual magnetism which exists in all soft iron causes the electro-magnets to excite an Electric current, at first very small, in the coils of the armature. This current is collected by the brushes, and allowed to pass through the coils encircling the soft iron electro-magnets. The latter straightway become electro-magnetic, and each turn of the armature increases the electro-magnetic power, until, in a very short time, the normal strength is reached. All further current then produced, with the exception of a fractional quantity to maintain the electro-magnet, passes into the cables and is available for use.

The action of the dynamo has often been compared with that of the water-pump, where, by setting the plunger in motion, a flow of water is caused in the water-pipes, and in the same way, by rotating the armature of the dynamo, a flow of Electricity is excited in the conducting wires.

The amount and strength of the Electric currents generated are almost exactly proportional to the amount of power expended in revolving the armature, and in this

respect the dynamo may be considered as an apparatus for converting mechanical power into Electrical Energy.

The accompanying illustration shows the well-known



Edison-Hopkinson continuous current dynamo, which may be taken as a good representative type. By comparing the illustration with the diagram of the magneto machine, the relative arrangements of the armature A, A, and, in this instance,

Continuous Current Dynamos.

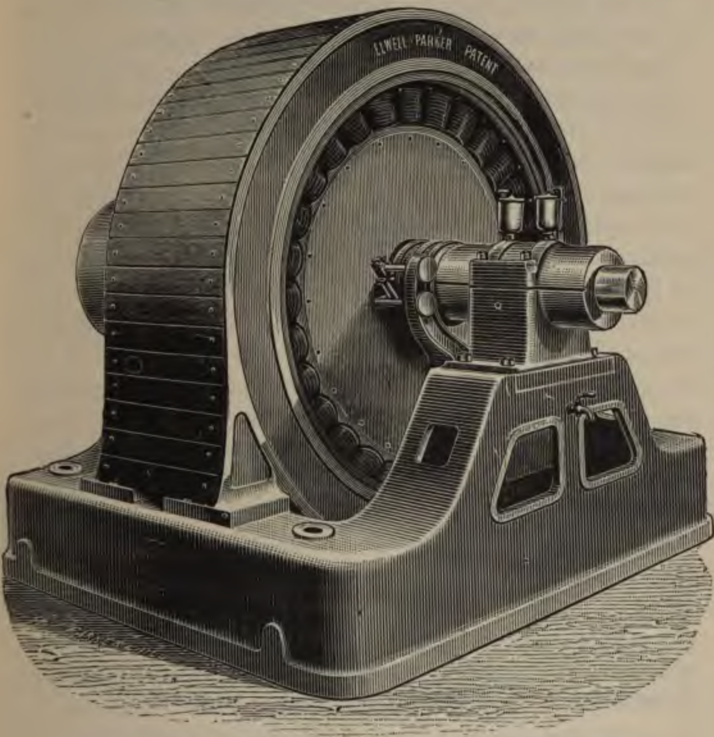
the electro-magnet M, M, will be seen. The latter consists of two columns of soft iron encircled by coils of insulated copper wire, and which are united together at the top by M 1, a heavy yoke of iron, thus together forming a magnet of the so-called horse-shoe shape. Between the ends or poles of this magnet revolves the armature A, A, which consists of a number of coils of insulated wire wound round an iron core. The ends of each coil are connected to copper strips or bars placed side by side forming a cylinder known as the Commutator C, from which the current is collected. Two sets of so-called brushes or collectors, B, B, are fixed upon the rocker D, an attachment which remains stationary unless it is necessary to adjust the position of the brushes. Attached to these brushes (one set being positive and the other negative) are E, E, cables conveying the current generated to the switch at top, by means of which connection can be made with the main supply cables; F, F shows the attachments by which current is conveyed to the electro-magnet, and G is the pulley attached to the armature shaft, which is thus revolved by the driving belt from the engine.

Those who desire to clearly understand how it is that the action of revolving an armature between the poles of a magnet (in other words, of moving a wire so as to cut magnetic lines of force) generates a current of Electricity, cannot do better than consult Professor Silvanus Thompson's work on Dynamo Electric Machinery. The principles and construction of the dynamo are here clearly and exhaustively set forth, and a description given of all the principal machines that have hitherto been designed.

Alternate Current Dynamos.

There is as great a scope for variety of type in the dynamo as there is in the primary battery, but existing types of dynamos may be roughly divided into those which furnish Continuous and those which furnish Alternate currents.

Many difficulties occur in the construction of continuous current dynamos to excite currents of over 2000 volts pressure (volt the unit of pressure), and when high-pressure currents are desired (see pages 21 and 91) dynamos con-



THE ELWELL-PARKER ALTERNATE CURRENT DYNAMO.

structed to excite what are called alternating currents are especially useful. Alternate currents are produced in practically the same way as continuous currents, but the dynamo is constructed with a number of magnets so con-

nected up as to generate waves of current, first in one direction and then in the opposite, the alternations or waves taking place many thousands of times in a minute. So rapid in fact are they that the current generated is practically a steady and continuous flow.

In the Elwell-Parker alternate current dynamo shown in the illustration there are eighteen magnets. The waves of current excited in the armature coils as they rotate are thus varied or alternated from positive to negative, every time they spin by the north and south pole of each of the eighteen magnets. There are thus thirty-six alternations every revolution, and as the machine revolves at a speed of three hundred and fifty revolutions per minute, $36 \times 350 = 12{,}600$ are the waves or alternations of the Electric currents generated by such a dynamo.

An "Alternation" is said to occur each time the current waves from the north to the south pole of the magnet, or from the south to the north, so that the complete change requires two alternations, and this is termed the "Frequency" of change, or sometimes the "Periodicity" of the current, there being so many periods of complete change per minute.

The "Periodicity" or "Frequency" of an alternating current is thus always half the number of the alternations.

Multiphase Current Dynamos.

Among the quite recent developments of the dynamo have been the use of multiphase alternate currents, which for transmission of power purposes especially have been shown to be of very considerable value, while their possibilities in other respects are only now being explored. (See page 131.)

In a machine constructed for two-phase or three-phase (multiphase) currents, the armature coils are so arranged in two or three separate circuits that as they spin by,

magnetic waves of current are successively excited in each coil. Thus in a two-phase current, the crest of the positive wave may be said to be at its height when the crest of the negative wave in the other phase is in the same position at the same moment.

The currents thus generated, whether two-phase or multiphase, are thus independent of and yet correlated to each other, and as the alternations occur several thousand times a minute, the Electric currents, as far as visible effects are concerned, form one steady and even flow of Electricity.

Multiphase current dynamos are constructed with a number of magnets similar to the simple alternate current dynamo, in fact certain alternate current machines, by winding in another series of armature coils between those at present used, can be readily arranged to excite two-phase currents.

Action of Different Currents.

It has been pointed out that the three classes of currents may be illustrated by the action of a magnetic needle surrounded by the conducting circuit. With a *continuous* current the needle assumes a fixed position, with an *alternating* current it swings from side to side, with a *multiphase* current it rotates on its axis.

Alternating or multiphase currents can be increased in pressure by what are called "step up" transformers, by which currents are *transformed up* from low pressure to high, or from a high pressure of say 5000 volts, up to extra high pressure of say 20,000 volts. Such "step up" transformers have converse action to the usual transformer described on page 90, by which high pressure currents are *reduced* to low pressure.

It is thus seen that by means of the dynamo, currents of any desired magnitude and of almost any desired pres-

sure can be efficiently generated, and that for whatever purpose dynamos may now be required, they can be scientifically constructed on well-defined lines. Ninety-six per cent. efficiency has been obtained, and considering that a small amount of power must always be lost in working any machine, it is not likely that the theoretical maximum will be further approached.

Many well-known names are associated with the evolution and development of the dynamo, and will be handed down to future generations of scientists as pioneers among Electrical inventors. After Faraday may be mentioned Siemens, Gramme, Edison, and Hopkinson, all of whom have done great service in bringing the dynamo to its present state of perfection, while Ferranti, Kapp, and Parker are mainly responsible for the present alternate current machine.

Motive Power.

The question is often asked, why is a steam-engine necessary for working a dynamo? and the reply is, that properly speaking the dynamo is only an agent for converting mechanical power into Electrical Energy.

It has already been shown that some energy must be expended in producing Electricity, and the dynamo is really only the intermediary. It does not *in itself* contain the power of producing electricity like a primary battery in which the zinc in the battery is consumed, but as in the thermo-pile heat has to be applied, and as in the frictional machine mechanical power is used for turning it, so until mechanical power is expended in revolving the dynamo armature no Electricity can be generated.

If Electricity is to be reliably and steadily generated by means of the dynamo, the arrangements for revolving the

armature—or, as it is termed, driving the dynamo—must be of first consideration. Indeed the failures in connection with Electric lighting have arisen not, as a rule, from the dynamo which has only one moving part, and is not liable to get out of order, but rather from defective arrangements in connection with the motive power.

The motive power employed must therefore be steady and constant.

Windmills. Although many efforts have been made to utilise the windmill as a source of power for driving small dynamos, so far they have not met with material success. Professor Blyth recently described a new form of windmill he had constructed on the American plan with a number of arms and blades of sheet-iron, and which had so far given gratifying results. He suggested that such an arrangement might be made serviceable for lighthouses, which are always in exposed situations, where wind is plentiful, and where a supply of coal for generating the Electric light could only be sent with difficulty.

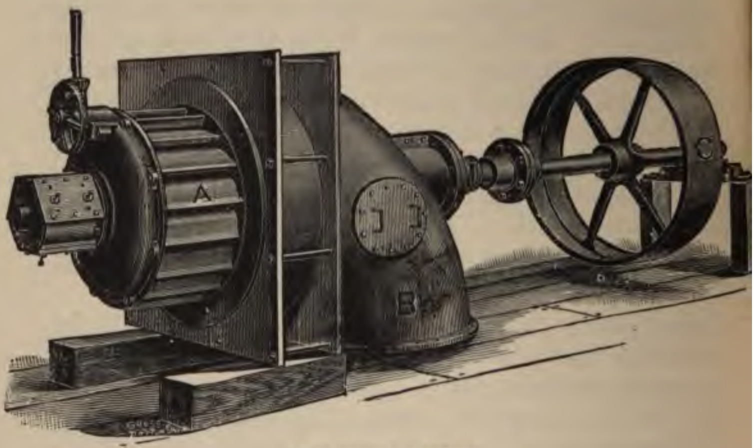
A dynamo worked in this way by wind might be arranged to charge sets of accumulators, so that with adequate storage capacity a constant supply of Electricity could be depended upon. Lighthouses would then be dependent on nothing but the energy of the fierce winds surrounding them to furnish the light to warn the seamen from the rocks.

Water Power. Where water power is available, the cost of producing Electrictity is reduced to a minimum. The heaviest item in the maintenance of all engines is the cost of fuel, whether it be coal, gas, or oil. If, therefore, it is possible to replace fuel by falling water costing nothing, or only a small rental, the application of this power cannot be too highly commended.

Even where water power is situated some distance off,

and the cost of cable from the dynamo to the point of consumption may appear great, it should always be remembered that after the erection of a turbine plant the only outlay to be considered is a small amount for attendance and depreciation.

The annexed illustration shows a well-known and very efficient turbine, with its cover removed, which will give a general idea of the principle of water turbines. The



THE VICTOR TURBINE.

falling water forces its way through the chute-case, A, on to a screw-bladed wheel inside, which is thus revolved, and in turn imparts its movement to the shaft carrying the pulley wheel, C. The water after being used passes away by the tail-waste, B. The best manner to describe the action of a turbine is to compare it to that of the propeller of a steamship. But in the turbine the action is exactly opposite, as it is the water which moves, imparting its power to the wheel of the turbine.

In the United States, where water power is abundant, many forms of turbines are made, vying with each other in economy of water, simplicity of construction, regularity of speed, and the readiness with which they can be adjusted to varying quantities of water.

The old-fashioned water-wheel, too, is often used for dynamo driving, and is quite suitable for the work, although the turbine, from the more efficient results obtained, is of course preferable.

Efforts are being made to utilise the energy of *flowing* water, and several forms of water motors have recently been experimented with. On such quick running streams as the Rhine or the Danube, excellent opportunities exist for obtaining power at present running to waste.

Steam-Engines.

Where natural power is out of the question, some form of engine must be employed, and the next most economical method of driving a dynamo is by means of the steam-engine. The invention of steam as a motive power has caused such a revolution in industries of all kinds, and its advantages are now so thoroughly appreciated throughout the civilised world, that no words are needed here on this score. Suffice it to say that the extreme steadiness of the steam-engine, and the fact that steam is consumed only in proportion to the work done, enables Electricity to be produced by steam driven dynamos on a commercial scale otherwise unattainable.

The usual method of connecting the engine with the dynamo is by means of a belt from the engine fly-wheel to a pulley fixed on the dynamo armature spindle.

With certain forms of steam-engines working at a high speed it becomes possible to couple them direct on to the armature of slow-running dynamos, thus doing away with any belting. Although the cost of such dynamos is greater

and the advocacy of high-speed engines by no means general, such a combination presents distinct advantages, such as economy of space, steadiness of running, &c., and most of the large Central Electric Supply stations are thus equipped. On shipboard the use of a combined engine and dynamo is very general.

For small installations it is preferable to use a slow-working engine, driving the dynamo from a belt, as it is more suitable to unskilled attendants, while the first cost is considerably less.

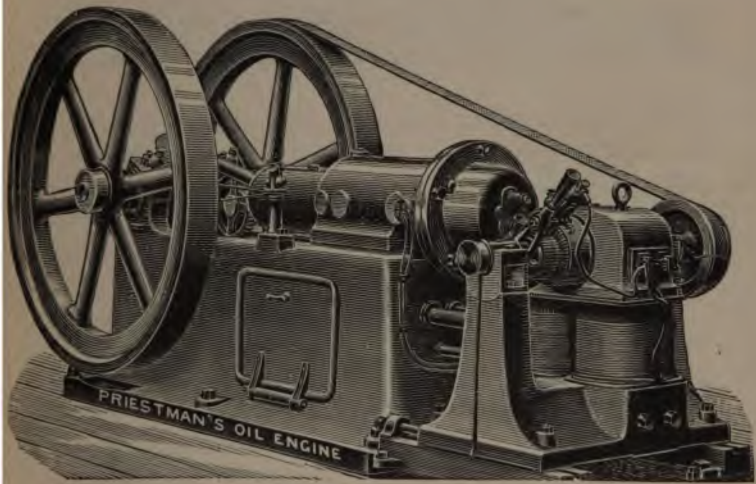
A variety of steam-engines, both vertical and horizontal, are now made by leading engine makers, where particular features desirable for dynamo driving, such as absence of parts requiring frequent adjustment, unvarying speed by automatic steam regulation, and so forth, are given special prominence.

Gas-Engines.

In cases, however, where a small amount of power is required for the dynamo, the gas-engine is often found more satisfactory than steam. Though the gas consumed in a gas-engine may be more costly than the fuel consumed in working a steam-engine to produce the same amount of power, still a gas-engine needs no stoking, and only requires to be started and stopped, and occasionally oiled. These services can always be performed by some one about the place, as it requires no special knowledge. For dynamos, however, requiring a large amount of power, steam is in many respects more suitable, and has hitherto been regarded as the more economical method. Recently, however, much attention has been directed to certain forms of gas as an economical power-producer, and the advent of large gas-engines competing with steam in economy and convenience for some purposes is certainly near at hand.

Many are prejudiced against gas-engines on account of

the nuisance sometimes caused by noise and vibration. Troubles of this kind may be avoided if the engine be properly fixed upon solid foundations well isolated from the surrounding buildings, and attention paid to certain other points which experience has shown to be of importance. Many important improvements have also been effected in gas-engines during the last two years, notably



ENGINE AND DYNAMO FOR ELECTRIC LIGHTING.

automatic gear for insuring regularity of speed under the varying loads caused by switching lights on and off, and gas-engines as now constructed may be considered a most efficient and economical motive power.

Oil-Engines.

Although oil-engines have only lately come into use, they must not be overlooked as power-producers. In places where coal and gas are expensive, such engines merit consideration, and in

the illustration a very compact arrangement of an oil-engine and dynamo is shown.

Briefly stated, the motive-power is obtained from mineral oil, which, having been mixed with air under pressure, is drawn into the cylinder and ignited usually by an Electric spark from a small ordinary battery supplied with the engine.

As with small gas-engines the attention required is not great, for should the oil become exhausted the engine only ceases to run.

CHAPTER III.

ELECTRIC LIGHTING BY THE ARC LAMP.

THERE are at present two methods of utilising Electricity for lighting purposes, the Arc and the Incandescent Lamp.

In both systems light is obtained from carbon heated to a white glow by the passage of the Electric current, the carbon in the Incandescent Lamp consisting of a fine thread which forms a *continuous* path for the Electricity, while in the Arc Lamp the carbon is thick, and *broken* at a particular point across which the Electric sparks leap, producing a brilliantly luminous effect.

Sir Humphry Davy, in 1800, mentions an experiment by which he then obtained sparks between two carbon points when connected up to a Voltaic Pile, and in 1810 he showed the Arc Light for the first time. This historic event took place at the Royal Institution, and it was only by means of some 2000 voltaic cells of a crude type that current sufficient for the purpose could be obtained. In this experiment, Sir Humphry Davy made use of two pieces of charcoal wood, which, on being brought near each other and connected to the battery, produced so bright a spark that the charcoal became ignited to whiteness. On withdrawing the points up to a distance of four inches apart, the current continued to pass through the heated air between, showing a most brilliant arch or arc of light. The arched form thus taken by the luminous

particles of carbon resulted from the upward rush of heated air, but the term "Electric Arch," or in its abbreviated form "Arc," is still retained as the name of the luminous space that is formed between the carbons.

Great as recent experiments appear to be, they have

THE ELECTRIC ARC.

only consisted in devising means for the better carrying out of Davy's original experiment. The heavy cost and inconvenience of obtaining sufficient Electricity from a *large number of voltaic* cells, for a long time deprived the

Electric Arc light of any value as a means of illumination, and until the invention of the dynamo furnished powerful Electric currents at a comparatively moderate cost, it remained a laboratory experiment and nothing more.

The luminous effect produced by the Electric arc is of an intensely brilliant nature. The points of the carbon rods become highly incandescent, and in addition the space between them is filled by a sort of flame or cloud of particles of white hot carbon. Of this dazzling mass of brilliancy some 85 per cent. of the light is emitted from the positive carbon, 10 per cent. from the negative carbon, and 5 per cent. by the flame of the arc between the points.

The heat, also, is so intense in the arc that the most refractory substances, such as platinum, sapphire, granite, &c., when introduced into it, fuse up and volatilise. On a large scale, it can be made use of as an Electrical furnace, and becomes the most powerful instrument yet known for chemical analysis, as mineral ores can be readily disassociated by its intense heat, and reduced to their elementary condition.

The carbons forming the Electric arc, being exposed to air, gradually burn away. This is due to volatilisation in the case of the positive carbon, which is consumed with twice the rapidity of the negative, where the waste, which seems to be caused by mere combustion, is also retarded by particles from the positive becoming deposited on the negative carbon. In this way the negative becomes slightly pointed, and a crater-like hole forms on the end of the positive. As the carbons waste away, the arc lengthens, and were not the rods brought nearer together the Electric arc would cease, from the current being unable to leap the intervening space. Should this occur, the arc can be again started by first bringing the rods into contact, and then drawing them a short distance apart.

"Arc lamps" are devices for holding the carbon rods so that they are first brought into contact and drawn apart to establish or "strike" the arc and then "fed" together, either continuously or at short intervals, to prevent the distance between the points becoming too great.

Various contrivances have been devised for automatically regulating the position of the two carbons. As early as 1847, a lamp was patented by Staite, in which the carbon rods were fed together by clockwork, the latter coming into gear whenever the current across the arc became reduced in strength on account of the lengthening of the distance between the carbons. Similar devices were produced by Foucault and others, but the first really successful arc lamp was Serrin's, patented in 1857, which has not only itself survived until the present day, but has had its main features reproduced in many other lamps.*

Arc lamps can be worked by either continuous or alternating currents, and, in some instances, such as for the Jablochkoff candle, the alternating system has been of distinct advantage. It has been already pointed out that the positive carbon is consumed with twice the rapidity of the negative, but where alternating currents of Electricity are employed this is not the case, as each carbon in turn rapidly becomes positive and negative, so that both

* No commercial use was found for the arc lamp until the year 1858, when the foundations of Westminster Bridge were being laid, and as the work could only be carried on at a low tide, it was necessary to work at night. A contemporary journal, in alluding to the fact, remarks :—"To effect this an electric light equal in intensity to twenty-two argand jets, was produced on shore by an electro-galvanic apparatus. The light was about two hundred feet distant from a stage or platform on which a number of men were employed in pile-driving, and was augmented by the use of a pair of Chappuis' reflectors. The light was rather flickering, but was sufficient for the purpose, being likened by the men to that of the full moon." This is probably the first instance of the Electric light being put to any practical use.

carbons are consumed in equal proportions. This has the result of diffusing the light more uniformly in all directions, as the top, which is usually the positive carbon, no longer having a crater-like form, does not direct so many of the light rays downwards. It is found, however, in practice that for general purposes the continuous currents are undoubtedly to be preferred for the steady working of arc lamps.

The development of the dynamo, a means of producing Electricity on a large scale economically, caused attention to be again directed to the commercial value of arc lighting. The Jablochkoff system in 1876 was in this respect especially serviceable, as it brought Electric light before the public in the simplest form yet introduced.

The Jablochkoff candle was devised to do away with the necessity of regulating the carbon by mechanism. In it the two carbons were placed side by side, separated by a thin strip of non-conducting material, thus uniting the pair of carbons into the form of a "candle." By using an alternating Electric current the carbons were uniformly consumed, the insulating material burning away at the same rate. Each candle lasted about 1½ hours, and it was customary to fix four sets to each lamp. The Avenue de l'Opera Paris in 1878, and later the Thames Embankment in London, were illuminated by their means. The light, however, is far more unsteady than with the ordinary modern arc lamp, and the Jablochkoff candle is now never employed except, possibly, in some of the Indian palaces, where the simplicity of the lamp permits of its use in the harems, where skilled labour cannot be admitted.

The attention that was directed to arc lighting, especially by the illumination of the Avenue de l'Opera, resulted in the invention of a large number of arc lamps with varying methods for gripping the carbons and feeding

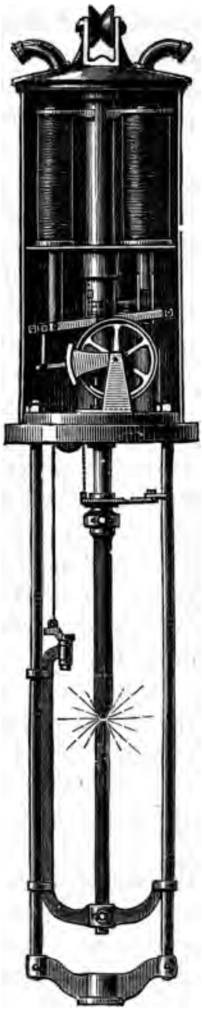
them towards one another as they became consumed. Brush, Siemens, and many others brought out lamps which did much to hasten a more extensive use of this system for lighting public thoroughfares and open spaces.

Others again, departing from the generally adopted methods of placing the carbons, devised various ingenious

THE NOVEL ARRANGEMENT OF CARBONS FOR ELECTRIC ARC.

contrivances by which carbon points might be brought together to form the Electric arc. None of these have survived, as the practice of the present day prefers the simpler methods. The illustration of the "Gerard" lamp, however, is interesting as showing the carbons brought together in the form of a pyramid, mechanism being

arranged at the top by which the carbons are all fed together as they become burned up.



The construction of an arc lamp does not require so much inventive capacity as ingenuity and good mechanical knowledge, and all the improvements that have been made consist more in the simplification of the feeding and regulating arrangements than in any alteration of principle.

To be thoroughly efficient an arc lamp must be self-adjusting in all respects, with the carbons regulated slowly by steady and continuous motion.

As modern arc lamps vary but little in external appearance, the Brockie-Pell lamp shown in the illustration may be taken as a typical representative. The adjusting mechanism is contained in the cylindrical box above, which is made damp-proof for out-door use.

The chief object in any such lamp is to keep the light uniform in quantity. It would appear, however, that some fluctuation is inevitable from the irregularities in the structure of all carbon rods.

The hissing, for instance, that is sometimes heard in arc lamps, is due to the use of carbons with too coarse a grain, or, again, to the arc or space between the carbons being too short.

Too long an arc, on the other hand, causes flaming and sputtering, which again may arise from impurities in the carbons. Although the steadiness of burning thus largely depends on the quality and homogeneity of the carbons used, there is little or no difference in the light-giving power of carbons of good quality.

Several efforts have been made to improve the quality of the light by adding volatile substances and by introducing gas through hollow carbons, but such experiments have not hitherto proved of much value.

It is a difficult matter to accurately measure the amount of light given from an arc lamp, both from the fact of the rays not being uniformly emitted in all directions, and from such rays having little in common with those of a candle. The light given depends upon the amount of current used and the size of the carbons. Mr. A. P. Trotter, in a valuable paper recently contributed to the Institute of Electrical Engineers, not only dealt thoroughly with value of light given from the Electric arc, but also gave some indications of the experiments he is conducting in the manufacture of coloured glass shades, with a view of obtaining artificial illumination similar to that of real daylight.

It has been pointed out that daylight in itself is an indefinite quality varying from the sunlight of the early morning to the uncertain tones of the midday sky, and while direct sunlight is yellowish, a clear blue sky gives a distinctly blue light. Many are accustomed to declare that the light given from the arc is a bluish light, whereas in the daytime, compared with the light given off from white clouds, it appears distinctly red. At night, on the other hand, the arc lamp naturally seems bluish as compared with the false standard of white light the eye has been *attuned to,* by the surrounding gas or candle illumination.

These defects may perhaps be corrected by the use of tinted glasses, where certain rays given off from the arc are intercepted and the harsh white appearance given a more pleasing tinge, so that a light is reflected at all times pleasing to the eye.

The lamps most generally used are 1000 to 2000 nominal candle-power, but during the past year much progress has been made in devising arc lights of small candle-power. There are now two or three very serviceable and efficient lamps constructed to give a light of some 200 candle-power, but the current used in working the regulating apparatus for the carbons is almost as much in these small lamps as in the far larger ones. Search lights of 10,000 candles and upwards are also manufactured for lighthouses and naval purposes. Ships fitted with arc lamps are now permitted to work through the Suez Canal at night, and a profitable business is done at Suez and Port Said by lending a complete apparatus to ships not provided with them.

Undoubtedly the proper sphere of the arc lamp is either out of doors or in buildings large enough to allow its rays to be dispersed without an unpleasantly dazzling effect. It is not suitable for reading-rooms from the slight fluctuations that occur from time to time, and the unpleasant effect the intense whiteness of the light has on the eye. The large amount of violet rays in the Electric arc make it especially serviceable for photographic purposes, while the vividness with which colours are brought out renders its use advantageous in weaving and calico printing mills.

The method of arc lighting shown in the illustration (p. 38) attracted considerable attention at the Paris Exhibition of 1879, and it is rather surprising that this highly effective arrangement has not since been more often employed. The arc lamp is placed in a cylinder

open at the top, and the light projected on to a large reflector. Any unpleasant effect of the arc light on the eye is in this way avoided, and the light given off from the whitened reflector is mellow and uniform.

For street lighting, railway stations, &c., and where a general illumination is required over a large area, the arc light is admirably suited. In America, arc lighting is more

INDIRECT ILLUMINATION BY ARC LAMPS.

extensively employed than in this country, and the streets of almost every city and town of importance are there lighted by this means.

The best effect for lighting broad thoroughfares is obtained by placing the arc lamp in the middle of the roadway. The St. Pancras Vestry have carried out the lighting of Tottenham Court Road in this manner, and it has many advantages over the plan of arc lamps used

alternately on either side of the roadway as with gas. For narrower thoroughfares, arc lamps could be suspended in the middle of the roadway by steel cables slung from each side of the street, and this plan, as carried out in many cities in the United States, presents a far from objectionable appearance.

The difficulty in the way of general street lighting has hitherto been the impossibility of obtaining efficient arc lamps of small candle-power suitable for lighting side streets. Again, as lights must not be fixed more than a certain space apart, especially in winding roads, a 100 candle-power arc lamp would only replace some two or three gas lamps, each giving 12 candles of light. As much more light than this would be given by the arc, the cost is proportionately greater, and this, when applied to an area containing a large number of small streets, makes the cost for arc lighting at present much greater for general street lighting than the cost for gas.

CHAPTER IV.

ELECTRIC LIGHTING BY THE INCANDESCENT LAMP.

ELECTRIC lighting would never have achieved the popularity and success which it at present enjoys if it had been confined to the arc lamp. As a matter of fact, the arc light did much in the earlier days to render Electric lighting unpopular. People felt that so glaring a light could never displace the soft and mellow glow of gas or candles to which they were accustomed, and that unless some form of Electric lamp could be devised to satisfactorily replace these, Electricity would never be generally adopted for domestic lighting,

The incandescent lamp, however, solved all the difficulties, and it may be best described as an arrangement by which a carbon filament is heated by Electricity to a white glow or incandescence.

The resistance which any bad conductor offers to the passage of the Electric current produces heat, and when the substance is of high resisting power the intense heat causes the substance to glow and give forth light. If the process be continued a white heat is obtained, until finally the substance, being exposed to the air, is either melted or burned up. By enclosing it, however, in an air-tight globe, the vacuum surrounding the glowing substance prevents any combustion, and the substance is thus not consumed.

All this was well known to scientists for many years,

and from time to time experiments were made with certain substances that would not readily melt or burn up. Platinum and carbon were found especially suitable. In 1845 a patent was taken out for the incandescence of carbon in a vacuum, and again in 1858 a lamp was patented where the illuminating current was sent through a glowing platinum spiral. The idea throughout these early inventions was to produce light by concentrating resistance to the passage of the Electric current at a given spot.

Although in these laboratory experiments a perfectly steady light could be produced, much had to be done in other directions before any really successful result could be attained. As in the case of the earlier attempts with arc lighting, the means of obtaining electric currents were limited to the Voltaic Battery, while the devices for exhausting the globes and producing a vacuum were still very primitive.

The incandescent lamp, indeed, is another of many instances where inventions have been made possible by other and independent scientific work. The construction of dynamos enabled Electric currents to be efficiently generated either on a large or small scale, while Professor Crookes by his researches on the vacuum, and Dr. Sprengel by his development of the air-pump for producing a good vacuum, did much to assist the experiments on the present incandescent lamp being brought to a successful conclusion.

It was in 1879 that the world was startled by the rumour that Edison had discovered the subdivision of the Electric light. Looking back now, it becomes difficult to appreciate all that this implied at the day when the only subdivision then known was that of the Jablochkoff system *mentioned* in the previous chapter.

The ubiquitous newspaper correspondents had long had their curiosity aroused by wonderful doings at Menlo Park, where Mr. Edison at that day had his laboratory, and it was due to the indiscreet interviewer that the world was thus prematurely informed of the great work Mr. Edison was engaged on. A platinum wire was first used by Mr. Edison, who trod in the footsteps of the earlier experimenters doubtless in the hope of improving and perfecting their early attempts. Laboratory experiments, however, soon showed that the glowing platinum wire would not long withstand such high temperatures. No sooner was Edison aware of the defects of his Platinum Lamp than, taking up carbon, he with inexhaustible perseverance examined every carbon-producing substance, including Chinaman's hair, until finally he fixed upon strips of carbonised bamboo as the best filament for his lamp. Several experienced assistants were at once despatched to Japan and different parts of America in search of varieties of bamboo, while Edison himself was perfecting the processes, in the laboratory, by which the filament should be enclosed in an air-tight globe with a view of preventing combustion. At last, after much arduous work and many disheartening failures, the Edison Carbon Incandescent Lamp became a commercial reality. The writer has often heard him tell the tale of the excitement of these early days: how, when on the verge of success, some unforeseen catastrophe would destroy the work of days, and the whole process had to be repeated again and again until finally, as hour after hour went on and the experimental lamps still burned brightly, it was joyfully recognised that a filament had now been obtained that would last, and the tired workers could go back to their beds.

Mr. Swan, of this country, had also been working on an *incandescent lamp* so early as 1860, using a filament of

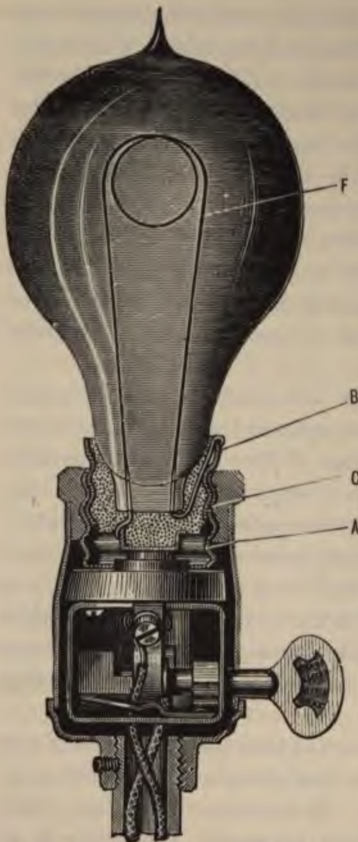
carbonised paper. Debarred then by the same difficulties of obtaining a good vacuum and an efficient supply of Electricity as others had experienced, he once again set to work in 1877, and succeeded in producing almost concurrently with Edison an efficient lamp with a filament of carbonised cotton. Other workers, too, were quickly following in their footsteps, and Maxim, Siemen, and others invented lamps, all having the same general characteristics of a carbon filament heated in a vacuum by Electricity to a state of glowing incandescence.

Such, shortly, is the history of the incandescent lamp, and although Mr. Edison was not the first man to produce an Incandescent Electric Lamp, he was undoubtedly the first who made one that was a practical and commercial success.

Mr. Edison, however, was not content with inventing an incandescent lamp, but completed the whole system for the generation and distribution of Electricity in connection with it. This system, the completeness of which was characteristic of the man, comprised switches, safety fuses, key-lamp holders, swing brackets, and all the other appliances that the public had long been familiar with in the use of gas. When the Edison system was shown thus complete at the Paris Exhibition of 1880, it was at once recognised that the era of incandescent Electric lighting had arrived.

In England the best features of both the Edison and Swan lamps have been utilised in the manufacture of the well-known "Ediswan" lamp. It consists of a glass bulb, from which the air has been extracted, rendering it as nearly as possible a perfect vacuum. Inside the bulb a carbon filament, F, is fixed, its two ends being connected to platinum wires passed through the glass when hot, and hermetically sealed. These two platinums are

connected up, the one to the screwed brass band, B, the other to the brass cap, A. A and B are kept apart by the plaster-of-Paris division, C. The lamp is connected up by simply screwing it into a socket as shown, where there are corresponding surface contacts, to which the Electric supply wires are connected.



THE EDISWAN LAMP AND SWITCH SOCKET.

The filament of the "Ediswan" lamp is made of carbonised cotton or thread, a modification of Mr. Swan's method, and which, in this country, is now considered preferable to carbonised bamboo. The Electricity finding its way through the contact pieces, A and B, is expended in overcoming the resistance of the filament to its passage through it. In this process the filament is raised to a yellowish-white glow. Although intense heat is produced by the process and a bright light is given, the filament, being in an air-tight space, is not consumed, nor *is any appreciable* heat given forth from the globe.

Every one is familiar with the pleasant, mellow light of the Ediswan lamp. It gives a brighter and clearer light than gas, but without the glare of the arc lamp. Enclosed in its little air-tight globe, it is impossible for good air to be consumed or bad air given off. The vital importance of this fact cannot be too fully appreciated. The harm done to health and property by gas and most other illuminants is well known, but the following figures, which have been often quoted elsewhere, deserve to appear in these pages:—

SANITARY ADVANTAGES OF ELECTRIC LIGHT.

Light-producing Material equal to 12 Standard Candles.	Cubic feet Oxygen Consumed.	Cubic feet Air Consumed.	Cubic feet Carbonic Acid Produced.	Cubic feet Air Vitiated.	Heat—lbs. of Water raised 10 deg. Fahr.
Cannel Gas	3·30	16·50	2·01	217·50	195·0
Common Gas	5·45	17·25	3·21	348·25	278·6
Sperm Oil	4·75	23·75	3·33	356·75	233·5
Benzole	4·46	22·30	3·54	376·30	232·6
Paraffin	6·81	34·05	4·50	484·05	361·9
Sperm Candles	7·57	37·85	5·77	614·85	351·7
Wax	8·41	42·05	5·90	632·25	383·1
Tallow	12·00	60·00	8·73	933·00	505·4
Electric Light	**None.**	**None.**	**None.**	**None.**	**13·8**

The above figures are taken from Dr. Meymott Tidy's well-known work on Modern Chemistry.

It is almost unnecessary nowadays to detail the many advantages Electric light has in comparison with gas, oil, or other illuminants. The latter blacken ceilings and paintings, destroy decorations and books, and at the same time are always a source of danger from fire and explosion. The incandescent light has none of these disadvantages, and when a few ordinary precautions are taken all risk of fire is reduced to a minimum. The incandescent lamp cannot explode, flare up, or be blown out, and the mere fact that matches are dispensed with is in itself a gre

safeguard. In the event of a lamp being accidentally broken when alight, the carbon is consumed on exposure to the air, and the light becomes at once extinguished. All that is then required is a new lamp, which can be readily screwed into the socket by any one.

Incandescent lamps are made to burn at different pressures or "voltage" (from the volt the unit of pressure), but no durable lamps are at present made capable of withstanding a higher pressure than 110 volts. It will be seen in Chapter VIII. what an important bearing this fact has on the distribution and supply of Electricity.

The cost of incandescent lamps has hitherto formed a considerable item in Electric lighting, owing to the price charged by the Edison & Swan Company, who expended large sums in acquiring and maintaining the patent rights giving them the monopoly of manufacture. This monopoly has now terminated. What is known as the "Flashing" patent, by which the filament is rendered uniform in size and quality, expired on November 28, 1892, while the famous Edison master patent of November 10, 1879, which has been held by the English courts to cover all lamps consisting of an exhausted glass globe with leading-in wires and a carbon filament, ceased on November 10, 1893.

The competition in the manufacture and sale of incandescent lamps has already reduced the price to 1s. 9d., and lamps in use on the Continent are being offered at considerably less than this.

Cheap lamps are already coming over in shoals from abroad, and it is only experts who are in a position to say what lamps are good and can be used without infringing the various minor patents that the Edison & Swan Company still hold. A few words of warning also against the indiscriminate purchase of incandescent lamps may not be out of place even now, as with free trade in incan-

descent lamps, rival manufacturers will for some time bewilder the unfortunate consumer with the merits of their respective manufactures.

Much of the cost in making incandescent lamps arises from the process for thoroughly extracting the air, and if the vacuum of an incandescent lamp is at all faulty the lamp itself becomes extremely hot. Again, the slightest flaw or irregularity in the filament materially affects the life and efficiency of the lamp, so that the false economy of many of the cheap foreign lamps can be easily appreciated.

Even with the best incandescent lamps there is a noticeable decrease of candle-power after a more or less lengthy period of use. This is due not so much to the blackening film formed on the glass bulb* as to the change which takes place in the nature of the carbon filament itself. It has been shown by experiments on certain incandescent lamps of foreign manufacture, that this change and consequent falling off in the candle-power of the lamp frequently occurs at a very early stage of their life.

An incandescent lamp which deteriorates thus rapidly, and while absorbing *more* Electric Energy gives out *less* light, is not a serviceable or economical lamp for the consumer. A lamp of low price will not by any means necessarily be a cheap lamp, as the gradual change in its candle-power might be such that it would be better to throw it away than to continue to burn it at a low efficiency.

It will be found that a lamp of careful manufacture in which the efficiency is high, and the standard and quality of the light maintained towards the end of its life as at the beginning, is well worth an additional few pence.

Although lower priced lamps will sensibly affect the cost of Electric lighting, the great improvement to be

* Caused probably by the condensation of carbon vapour volatilised from the substance of the filament.

looked for in this direction is a lamp which, with the qualities named above, will give the *same* light, although consuming a *smaller amount* of current, which, of course, means Electric light at a lower cost. Hitherto, many of

SPECIAL FORMS OF INCANDESCENT LAMPS.

the efforts to improve the economy of the lamp have resulted in shortening its life, and owing to the high price formerly charged, consumers naturally desired that the lamp should last its full eight hundred or a thousand hours.

With an incandescent lamp costing a shilling or so,

gth of life will not be so much sought after as the ire to obtain as much light *of a uniform quality* as is sible with the smallest consumption of Electricity, n if the lamp last only four hundred hours. This will far better for the consumer, as he will then perhaps two 8 candle-power lights from the current now orbed by one, and although the lamps themselves may

SPECIAL FORM OF INCANDESCENT LAMP.

; half the time, the cost of lamp renewals even then *double* the number of lights throughout the year will no greater than at present. In any case, the effect of apetition in the manufacture of incandescent lamps st be to make the Electric light a still more formidable ponent to gas than even at the present moment.

The illustrations show special forms of incandescent

lamps made for decorative purposes, and a variety of elegantly shaped pearline and opalescent glow lamps may soon be expected.

A type of lamp made by the Edison & Swan Company is also shown, where the filament is projected forward in the bulb, which is sometimes also made with a flat or oval side. For surgical purposes, or where it is desirable to have the source of light in a given plane or close to the point of application, there is no method equal to Electrical lighting, which so admirably lends itself to every requirement.

SURGICAL INCANDESCENT LAMP.

The incandescent lamps in general use are of 8 or 16 candle-power, but lamps of 32 and 50 candle-power are made for use where a more powerful light is required. It may be taken as a general rule that the higher the candle-power of the lamp the more economical it is as regards consumption of current. Thus it is found that one 16 candle-power lamp will not require quite so much current as two of 8 candle-power. On the other hand, of course, one large lamp does not distribute the light so well as a number of smaller ones.

"Sunbeam" Lamps.

High candle-power incandescent lamps, often termed "Sunbeam" lamps, have recently come much into use, and bid fair to successfully rival arc lights for some purposes. Such lamps are now made from 100 to 500 and even 1000 candle-power. Their light is steadier and less dazzling than that of the arc, but the relatively large amount of *Electric* Energy they consume, and the expense of the

lamp renewals (from 12s. upwards) have hitherto acted against their extensive use.

Now that the protective barrier of patent rights has been broken away, the improvements in manufacture that competition is bringing about, together with the lower price of some 5s. for the lamp, will cause a rapid development in the use of high candle-power incandescent lights during the next year or so.

CHAPTER V.

THE STORAGE OF ELECTRICITY.

OF all facts relating to Electrical science, perhaps the greatest stumbling-block to the uninitiated is the conception of how such an almost incomprehensible force as Electricity can be stored away in commonplace-looking glass or wooden boxes, and put aside on a shelf to be used when required. And yet, when the truth is explained, and this apparently inexplicable phenomenon is found to be entirely the result of simple chemical processes, the action of which can be accurately analysed and the causes accounted for with unerring certainty, the whole seems quite clear.

Accumulators.

Electricity is stored in what are called accumulator cells or secondary batteries. The principle upon which they work, discovered as long ago as the year 1859, by Gaston Planté, was not developed into anything like a practical form until 1881, when Sir William Thompson published a letter in the *Times*, announcing the receipt of "a marvellous box of Electricity" which had been sent to him in Glasgow from M. Faure in Paris. The host of "inventions" following on this publicity, although leaving considerable scope for further improvements, helped to make the storage of Electricity a commercial reality, and accumulators are now, in many branches of Electrical work, almost indispensable.

The accumulator is called a *secondary* battery, to dis-

tinguish it from the primary battery, the difference being that whereas the latter produces current at the expense of its own elements, and continues to do so until those elements are exhausted, the accumulator, though not itself able to generate Electricity, has the power of *storing up* for future use Electrical Energy produced from other sources. The elements of the accumulator do not consume and require replenishing, as is the case with the primary battery. Although certain chemical changes take place when Electricity is used from an accumulator, on being recharged the former condition is acquired, all the changes that have taken place being reversed, and the chemicals reformed in their old combinations.

The function of the accumulator will be readily understood by comparing it to a gasometer. After this has been filled the gas may be drawn off at any time as wanted, until the gasometer is empty; it then requires refilling from the retort. An analogous process takes place with the accumulator. In this case the dynamo corresponds to the retort and supplies current to fill or "charge" the accumulator. When fully charged the latter will retain the Electrical Energy for any reasonable time, or will, when called upon, give out any quantity desired until its charge is exhausted. Then, like the gasometer, it requires recharging.

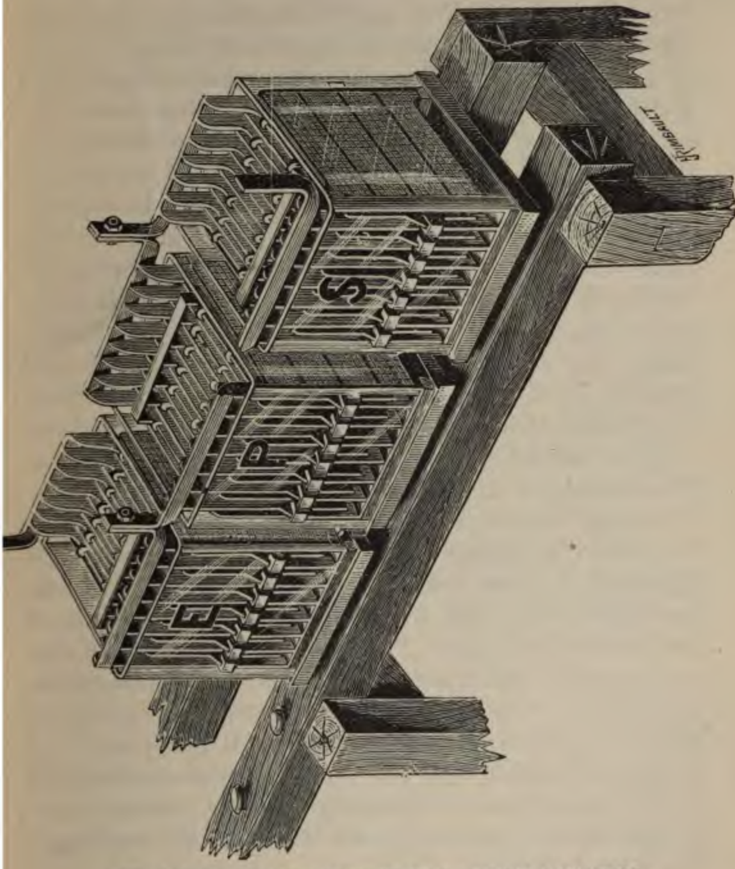
Now, the advantage in many cases of this system of storage as an adjunct to the dynamo is at once apparent. Let us take the case of a dynamo used for the production of Electric light. It is not always convenient to run the machinery whenever the light is required, and with a set of accumulators this is not necessary. By driving the dynamo for a few hours every day and allowing the current to store itself in the accumulators, Electricity is always available, whether the dynamo is at work or not.

and it will readily be seen that this method does away with the need for working machinery at night. In a private installation it would be impracticable and absurd to keep the machinery running all night to supply a few lamps; therefore the Electric light must either be dispensed with in the bedrooms, for which it is so eminently suited, or accumulators must be employed.

It has often been urged against the use of accumulators, that a considerable percentage of energy is lost in the process of charging and discharging them. This is true; but if an engine and dynamo have to be continually at work, no matter whether ten or a hundred lamps be alight, there must also be a great waste of energy, for although an engine when worked up to its full power is very efficient, the loss in coal and labour when running with a light load is a more considerable item than any waste of power involved by the use of an accumulator.

The illustration on the next page shows three cells of the most approved type, and the method of connection. The enclosing case or box is usually made of glass, though formerly teak was employed; glass, however, allows the interior of the cell to be inspected without the removal of its contents. The cell contains a solution of dilute sulphuric acid, and immersed in this are two sets of lead plates, those of each set being severally connected together by a bar of lead at the top. As will be observed in the illustration, the two systems of plates intersect each other, alternate plates being connected to opposite bars; of these one is positive, and is in connection with the positive cable from the charging dynamo; the other is negative, and to this the negative cable is attached. Each plate is kept apart from its neighbour by "separators" of an insulating material. The plates are perforated like a honeycomb and the interstices filled, the negative with a preparation

of oxide of lead called litharge and the positive with red lead called minium.



THE ELECTRICAL POWER STORAGE CO.'S ACCUMULATOR CELLS.

To account for the construction of the accumulator and *the action of its* elements, perhaps the best way is to detail

the circumstances which led to the discovery of its principles. It was known that when two wires were immersed in water, and a current of Electricity caused to pass through the liquid from one to the other, the water was decomposed, and its elements, oxygen and hydrogen, given off as gases at the positive and negative poles respectively. But when, in further experimenting, lead plates were substituted for the wires and the water slightly acidulated by the addition of sulphuric acid, it was found that a deposit of oxide of lead was formed on the positive lead plate. On the Electric current being discontinued and the lead plates connected to a galvanometer, a small current of Electricity was observed to pass through the instrument, and its appearance was rightly accounted for by the explanation that a reaction had set in—the chemicals forced apart by the decomposing agency of the Electric current were finding their old combinations, and the current then observed was an evidence of the internal work going on. This indeed was the modern accumulator in embryo.

Instead, however, of using plain lead plates and "forming" them by charge and discharge in the manner just described, they are now artificially formed by loading the apertures of the lead with the required preparations of red lead and litharge. The effect is just the same, and much trouble and expense is saved by not forming them electrically. The multiplication in modern accumulators of the original single plate enables a larger quantity of current to be dealt with, and when a dynamo is connected to an accumulator for charging purposes, its cables are attached to the connecting bars of the positive and negative sets of plates.

The state of things in the charged accumulator may be described in simple language by saying that certain chemical elements have been forcibly separated from their

original combinations by the passage of an Electric current; they are at present compelled to remain—so to speak—in unwonted positions, and are naturally anxious to regain their former state. It is like pulling out a piece of elastic: as long as it remains stretched out the power that was used to stretch it remains latent, but the moment the ends are released the elastic springs back to its original state, and the power first used is evinced in the recoil. So with the accumulator: for the moment its positive and negative poles are connected by a wire, the transformed elements hasten to regain their former conditions, and in so doing produce an Electric current.

In the best accumulators energy may be stored with a loss on discharge of only about 20 per cent.—that is to say, if a battery be charged for 10 hours it will give out a current equal to that of the charging current for a period or 8 hours. But it is sometimes required to draw current out of accumulators at a faster rate than it was put in—say, for instance, to consume in 4 hours a current which, in the ordinary course, should last 8 hours. Until recently this was impracticable, owing to the fact that the plates buckled together under the increased vigour of the chemical action. Now, accumulators have been devised in which the current may be very rapidly discharged in the event of sudden demand for a large supply.

There is one point that perhaps requires elucidation in order to prevent a mistaken notion being entertained regarding accumulators. People may say that if 50 cells are necessary for 50 lights, then only 1 cell should be necessary for 1 light. This is logic, on the face of it, but it is not Electricity. As before mentioned, lamps are constructed for different pressures of current, and the number of cells must be decided by whatever pressure is most suitable and economical for the installation. There-

fore a greater or less number of lights entails larger or smaller *sized* accumulators, but does not necessarily influence the *number* of cells.

Take for example two houses, one fitted up with 50 16 candle-power lamps, and the other with 100 lamps of similar candle-power, the lamps in each case being constructed for the same pressure of current; then the *number* of cells in each house will be identical, but those in the latter house must be double the *size* of those in the former.

Several forms of small portable or pocket accumulators are now made, and such arrangements are very useful where a safe and convenient form of hand-lamp is sought for. Miners especially would find such lamps a great boon, but the weight of pocket accumulators where the light is required continuously for some eight hours or more without recharging has hitherto been against its general adoption in mines. For small reading lamps, surgical lamps, and fairy lights for stage effects, where the Electric current is only required for intermittent periods of half-an-hour or an hour, comparatively light accumulators are made, and being curved as shown, are easily carried in the pocket.

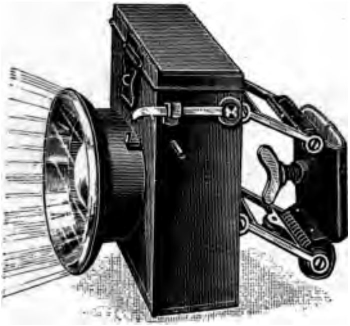
POCKET ELECTRIC ACCUMULATOR.

The charming effects now so general at the spectacular theatres are all obtained by means of such portable accumulators, and many different forms of Electric jewellery, such as tiaras, brooches, &c., are now manufactured.

The recharging of these small accumulators is easily effected from the house supply mains, unless the supply

be from a company using the alternate current system, which, as explained on page 92, is not serviceable for charging accumulators of any kind.

Body-belts for holding three or four pocket accumulators are made, and portable hand lamps and cycle lamps work



ELECTRIC CYCLE LAMP AND ACCUMULATOR.

ELECTRIC HAND LAMP AND ACCUMULATOR.

very well with a small accumulator attached. A charged accumulator for all such purposes is far preferable to a primary battery.

CHAPTER VI.

THE WIRING OF A HOUSE.

NOT the least important branch of Electrical work is the fitting up of buildings with properly arranged systems of cables and wires, to serve as conductors for the Electric current when used for illuminating purposes. It is a branch which should be carefully distinguished from the fixing of the Electrical installation, that is to say, the dynamo, engines, accumulator, &c., for it is work of an entirely different nature. So different, in fact, that it is usual to employ separate workmen for the two branches, each man having a special knowledge of his own business.

The quality of the wiring work in a house is a great deal more important than many people imagine, and the few accidents that have occurred in connection with Electricity have all been traceable to sheer carelessness or the use of bad materials.

The public, as yet, knows so little about its technical details, that any one contemplating the adoption of Electric lighting would do well to think twice before accepting the lowest tender for the work. In the case of gas or water pipes, if the work be badly done faults soon become noticeable, but with Electricity detection is not so simple a matter, although the results of bad work are equally serious.

To those conversant with the small problems involved *in maintaining* good insulation of Electric light house-

wiring, it seems incomprehensible how owners and tenants can complacently employ their decorator, their builder, their jobbing plumber, or, of course, any one who can fix an Electric bell, to install wires and cables for Electric light purposes. True, it is simple work, there is nothing in it but putting a few india-rubber coated wires into wood casing, but, unfortunately, if it is not properly and well done, uncomfortable consequences will inevitably ensue.

Electricity, when employed for artificial lighting in houses, must have a well-insulated metallic circuit to flow in, and this can only be obtained by careful workmanship, good material, and attention to such details as joints, switches, safety fuses, &c.

Conductors.

As copper wire is always employed for Electric lighting work, it may be wondered why wire of some cheaper material is not used. The reason is a very simple one.

The substances that can be employed for conveying Electricity vary very considerably in their conducting qualities, and to convey Electric currents for lighting purposes the conductors must be of "high conductivity," *i.e.*, capable of conveying the Electricity with as little loss as possible. The following is a list of the best conductors, placed in the order of their conductivity: *silver, copper, gold, zinc, platinum, iron, tin, lead, &c., &c.*

The precious metals, silver, gold, and platinum, may be at once excluded from the list, though the last mentioned is used in the Ediswan lamp, on account of its expanding equally with the glass when the lamp warms. Zinc, apart from other objections, is not sufficiently ductile to be drawn into wire; tin is expensive and inferior to copper; thus the list is reduced to copper, iron, and lead. These are all employed, more or less, for Electrical purposes Iron wire is extensively used for telegraphy, but like lead

is not of sufficient conductivity for conveying large quantities of Electricity. An iron wire would be much cheaper than the same sized copper wire, but to carry the same quantity of Electricity (at the same percentage of loss) the iron wire would require to be nearly six times the size of the copper wire.

Copper, which practically ranks highest in the list, is moreover a most suitable material. It combines all the desirable qualities, being readily procurable, ductile, pliable, &c. The purer the copper the better the conductivity of the wire, so that a wire in which a considerable percentage of impurities occur is as much to be avoided as one that is too small. Some of the best cable is guaranteed as high as 99 per cent. pure copper, and nothing less than 96 per cent. should be employed. In Electric work it is usual for all the larger wires and cables to be constructed of a number of strands of small wires, as this gives increased flexibility to the cable, and allows joints to be more readily made.

Insulation.

Bare copper Electrical conductors are of course impracticable for house-wiring, although they are employed by some companies for street mains, as mentioned on page 108.

For house-wiring, and all kindred work, every conductor should be thoroughly and carefully insulated.

The best insulators are, of course, those substances that offer the greatest resistance to the passage of Electricity. *Dry rarefied air* stands highest on the list; and after this, the best are *glass, ebonite, paraffin, shellac, indiarubber, gutta-percha, sulphur, silk, porcelain, &c.*

All these are more or less used for Electrical purposes, but of course are not all suitable for covering wires and cables. Gutta-percha, which has been so largely used for telegraphic and submarine work, is not serviceable for

Electric light work, on account of its yielding so readily to the influence of heat. Oil has recently been again attracting attention, especially as a cheap means of insulating cables for underground systems of Electric distribution. It has certain disadvantages, and may be at once dismissed as unsuitable for house-wiring.

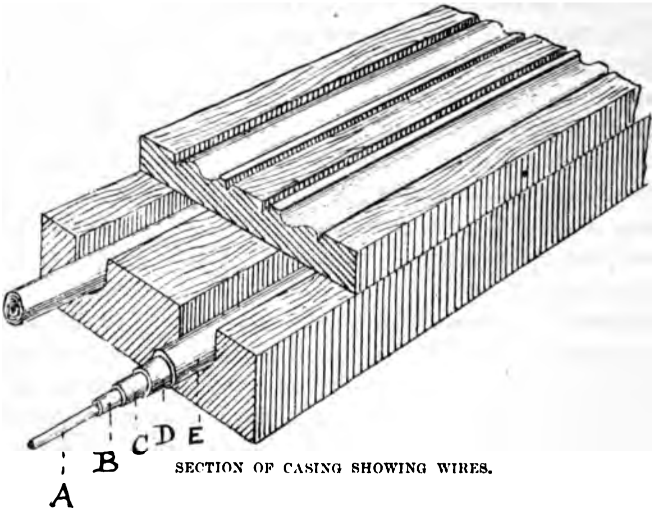
Electric light wires are now principally insulated either with indiarubber, or a fibrous material such as jute, steeped in a resinous or bituminous compound. Indiarubber is usually vulcanised, *i.e.*, treated with sulphur, to make it harder and more durable, and good vulcanised indiarubber insulation is generally considered the best. This, however, like most other things nowadays, is frequently adulterated, and cheap rubber insulation is seldom good.*

Again, the *amount* of *insulation* on a wire is of importance, and to show the extent to which the *quality* and *amount* of the insulation affect the cost, it may be remarked that so-called indiarubber insulated wires vary as much as 200 per cent. in price. Sooner or later, inferior insulation and indifferent work in Electric lighting are bound to show themselves, but if well-insulated wires properly portioned to the Electric current they have to carry are once carefully fixed, they do not wear out with the passage of the current, and the insulation should last for many years.

In the illustration, the wires are represented with their insulation partly removed, in order to show its composition in wires of the best make. A, the copper wire, is

* In a paper read by the writer in April 1889, at the Institute of Electrical Engineers, on Underground Conduits and Electrical Conductors, the relative advantages of different insulating materials for high pressure currents were discussed, and there seems no reason to doubt th for this purpose at any rate a homogeneous insulation like indiarubber preferable to any fibrous insulation at present made.

usually coated with a thin layer of tin, to prevent decomposition of the rubber by the copper, and to enable joints to be soldered with greater convenience. B is a coating of indiarubber. C is vulcanised indiarubber. D is a



SECTION OF CASING SHOWING WIRES.

layer of indiarubber-coated tape, and after the whole has been vulcanised together the outer covering, E, consisting of braided tarred flax and preservative compound, is applied.

Casings.

It will be observed that the wires are mechanically protected by wood-casing, and laid into grooves. Sometimes metal pipes are employed, and they or the casings are fixed under floors, between partitions, &c.

As a rule, there is far too much anxiety displayed to bury the wires away in the most un-get-at-able places. *A neat casing* is by no means unsightly in bedrooms,

passages, &c., and if placed on the surface allows of ready access in the case, say, of more lights being added, or alterations being carried out. Two wires should be employed for every lamp, in order that the current may flow in a complete insulated circuit, and these wires are called respectively the positive and negative, or the flow and return.

Arrangement of Circuits.

The arrangement of circuits in a building requires great care and skill, and it is here if anywhere that an inexperienced engineer or an amateur will come to grief.

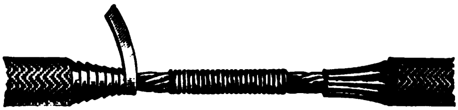
The most approved method (of which Mr. J. S. Cunnington was the originator here in 1881) is to divide the current up into a number of small circuits, as in this way faults, should they occur, are more readily found, and are less serious, as only a few lights are affected. Starting with the mains from the dynamo, or from the public supply, as the case may be, the current is conveyed to a central distribution-board. From this, small circuits are taken to the lamps, or in a large building cables are run to other branch distribution-boards, where the circuits are again subdivided. The value of such a system of distribution is well worth the slight additional cost involved over other systems employed. It is far safer, far simpler, and allows of a more equal distribution of current.

Troubles are often caused in house-wiring by using wires of too small a size for the current they are intended to convey, as, although a saving in copper is effected, it is with a loss of light and at a certain risk. When the wire is too small for the current it has to convey, it becomes heated and is a source of danger. Needless to say, the Fire Insurance inspectors are exceedingly particular on this point. The fault, however, is not always intentional, and it may be the result of ignorance or careless

workmanship—which emphasises the necessity of having the work carried out under experienced and competent engineers.

Joints.

Bad jointing of the conductors has been the most fruitful source of trouble and danger in Electric work. The illustration shows how a joint should be made so that the carrying capacity is as good as



in any other part of the conductor. The strands of the copper are first cleaned, then interlapped or scarfed, and finally, in the case of large cables, bound over with another copper wire. The insulation is then carefully made good, first with indiarubber solution, and then with indiarubber tape, bound tightly together to form a homogeneous and watertight connection with existing insulation. It is indeed well worth paying more for the Electric wiring of a house if, by employment of careful workmen, the proper jointing of the wires and cables will be attended to.

Damp is the great enemy of the Electrical engineer. All the long length of his wires, every joint and every connection, must be thoroughly damp-proof, or leakage and deterioration will ensue.

The dryest possible positions for the wires and cables must be selected, and, moreover, it must be borne in mind that a place dry at the time of fixing the cable may not always be in that condition. The contingency of a pipe bursting, a cistern overflowing, and a hundred other chances must be provided against. The reason for all

this caution is that water, or in fact liquid of almost any description, is a good conductor of Electricity (not so good a conductor as copper wire, of course, but still a conductor), and so, if the Electric wires become wet, the current leaks through and finds its way to the earth.

"Earth."

Sometimes troubles arise from what is technically called "earth," that is leakage (caused by dampness or faulty insulation) from one or both wires, passing by means of damp walls or other conducting substances to the earth. Some amusement has at times been caused by people taking this word literally, and in one instance the question was asked, "Why was not the earth removed from the house before the wires were put in?"

In the early days of Electrical science earth meant "earth" and nothing else, and it seemed natural to refer to "Mother Earth" as the great reservoir of Electricity. Although ideas in this respect have undergone considerable change, it is important in Electric lighting work to get as far away from "earth" as possible. Every effort, therefore, is made by means of good insulation to prevent the Electric Energy going to "earth," which may mean water or gas pipes, damp walls or plaster, which, by reason of the moisture in the brick, wood, or stone, become conductors.

Another fruitful source of trouble is what is termed "a short circuit." This is the result of leakage, by which current gets direct from one wire to the other by a short cut, instead of completing its circuit through the lamp. The natural tendency of Electricity is to take the shortest and easiest path. It has been well said, in connection with the Atlantic cable, that Electricity finds it easier to travel from England to America, through the thousands of miles of copper wire, than through the half-inch of

insulation encircling it. But once a short cut is made a rush of Electricity ensues through the weak spot, and in the case of currents used for Electric lighting the wires become heated, and a fire is liable to occur.

Safety-Fuses.

The foregoing, of course, sounds dangerous, and so indeed it would be, were it not for the preventive action of Mr. Edison's ingenious contrivance, the safety-fuse or cut-out. Such safety-fuses are now made of various types, but they all essentially consist in the insertion at some point in the Electrical circuit of a short length of fusible lead or tin wire, the size of which is determined by the maximum amount of current required.

The safety-fuse thus forms a weak point in the wire, so that should a short circuit or other accidental overloading of the wire take place, the lead fuse will be first affected, and at once melt without allowing the copper wire conductors to become overheated. Continuity is thus broken, and no more current can pass through the damaged circuit until the repair has been effected, and a new fuse, at the cost of a few pence, inserted.

In using gas we have no such safeguard as this; a leak is often quickly followed by a fire or an explosion. If there were some such contrivance as the safety-fuse, to at once *automatically* shut off the gas supply in that part of the house where a leak occurred, the Fire Brigade would have considerably less work to do.*

* Fires in One Year in New York City, caused by

Paraffin, Kerosene, &c.	259 fires	loss	$ 94,657
Gas	110 „	„	128,174
Matches, used for gas	35 „	„	22,570
Candles	88 „	„	30,667
Arc Electric Light	7 „	„	550
Incandescent Electric Light	1 „	„	insignificant.

[*From Official Report.*]

A house fitted with properly regulated safety cut-outs is perfectly safe—provided, of course, that all the other work is well carried out—and as far as the Electric light is concerned the Insurance Policy might be discontinued. Care, however, must always be taken not to use a fuse of a larger size than is actually required; for instance, a 20-light fuse would be of very little use to protect a 5-light circuit. But safety-fuses are now so constructed that it is *impossible* for a careless attendant *to use a larger fuse than the correct one*, each fuse being so made that it will only fit into a properly proportioned slot of the required capacity, and only such fuses should be employed if real safety is desired.

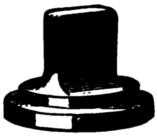
It is a great mistake to put safety-fuses on or near the ceiling, or on the skirting-boards, as is sometimes done. The best place for them is on the distribution-boards, where the small circuits leave the mains. The fuses are thus readily accessible, and by taking any of them out the different circuits of the house can be totally disconnected.

Switches.

Switches are another indispensable item in Electric lighting. The switch is the key or tap used for turning the lights on or off, and corresponds to the gas tap; but with this important difference—no matches are required, for the moment the switch is turned on the lamp is alight. It is merely a contrivance for completing or breaking the continuity of the Electric circuit.

As switches are constantly in use for lighting or extinguishing lamps, and are almost the only part of the Electric apparatus that the consumer directly handles, it is very desirable that switches should be of good design and construction, as well as easy in their working. Sometimes people, curious to know "how the Electric light looks *when it is going* out," will foolishly hold the handle

so that the contact pieces are kept at the separating-point. In a good switch it should, therefore, be *impossible* to hold the contact pieces partly on or off, as a partial contact will cause the switch to heat and fire. Several excellent



"QUICK-BREAK" SWITCH, WITH COVER REMOVED.

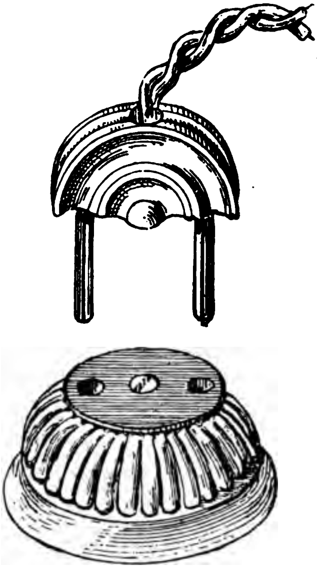
switches of high-class workmanship are now obtainable, and these should be insisted upon, as by the use of a cheap and too often inefficient form of switch a difference of more than a shilling per lamp may be made in the cost of the wiring.

Wall Plugs or "Shoes."

Another useful device for the detachment of portable lights is here represented, and its connection explains itself.

The convenience of such sockets fixed on he *skirting-board* in various parts of a room cannot be

over-estimated. By their use it is possible without trouble to connect up a portable light which can be moved about almost as freely as a candlestick. It is not necessary to have a separate lamp to each shoe-socket, as the plugs are all interchangeable, and when once the shoe has been fixed a connection can be made instantly.


"SHOE" AND PLUG FOR PORTABLE LAMP.

Lamp-Holders.

There are two forms of lamp-holders or sockets in general use. The one shown in the illustration on page 44 is the *Screw* Switch Socket, and connection is made by simply screwing the lamp into the socket. The "Bayonet" Lamp Socket, is also now largely used in this country. In the latest form the terminals and other metal parts conveying the current are so thoroughly surrounded by the insulating china that a short circuit or other accident is rendered impossible.

"P" erfect "I" nsulation System.

It is in the smaller matters that troubles usually arise, and experience has shown that good insulation depends largely on well-made lamp-holders, safety-fuses, and such like accessories. China is now almost exclusively used as an insulator in all these minor fittings, as it far surpasses slate or ebonite both as regards its fire-proof and its insulating qualities. Among recent improvements we

be mentioned an important alteration in the method of fixing the conducting parts of switches, safety-fuses, &c., into the china cases. It was found that such accessories, when fixed on damp walls, were liable to convey the damp into the wiring circuit through the metal parts piercing the china backs. As a good insulation is incompatible with damp or "earths," low insulation frequently resulted from this cause, although every precaution had otherwise been taken with the wiring work. In the Perfect Insulation System this defect has been overcome by arranging the conducting metal parts so that they do not pierce the china bases, which have only holes through them for the fixing screws, and these are not in contact with any of the parts conveying the current. Where the Perfect Insulation System is employed, damp cannot be thus introduced into the wiring circuit, nor does leakage of current so readily take place "to earth."

All such details as these, which the trained engineer thoroughly acquainted with his subject fully appreciates, do not appeal to the decorator, who readily undertakes wiring work so as to increase the total sum of his contract in a house; or to the plumber, unwilling to acknowledge that wiring for Electric lighting is different from tacking up wires for Electric bells. Much of the faulty Electrical work, however, has also been done by Electrical engineers, who should and often do know better. Estimating without knowledge, undertaking work at prices which it must be known the work cannot be properly carried out for, naturally result in the cheapest and commonest material being employed. Safety-fuses, switches, and other Electrical sundries that are out of date, and which makers are almost ready to give away, are usually in this way worked in.

As a rule the householder does not feel disposed to

employ a consulting engineer for what is after all a small work, but at the same time he is anxious that such work, involving more or less disturbance to the house, shall be skilfully performed and of a lasting nature. His proper and only course, therefore, is to entrust it to some firm—of whom there are several—whose experience, reputation, and integrity will ensure the work being done in as efficient a manner as is possible.

Cost.

With regard to the cost of wiring, much must depend upon the nature of the building, as the cost of labour is almost double where parquet floors, stone landings or concrete constructions are encountered. In some instances, where in addition to these difficulties the runs of the wire are long, the cost for labour alone has worked out at over 22s. per light. Even where ordinary floors or joists are found, the item for men's time, if good class and experienced labour be employed, is seldom under 12s. per light, and more if superintendence be added.

Where a large number of single lights are used, and there are long runs for the distributing cables, the value of the wires and cables is proportionately affected. The cost for cables and wires of high insulation for the lighting of an average house of say 50 to 100 lights may, however, be taken at 8s. to 10s. per light, for the copper conductors themselves. Grouping lamps in clusters reduces both the item for labour and the cost of the wire, while in the same way wall-plugs or lamps in inaccessible positions increase the respective charges.

The cost of good whitewood casings averages 1s. 3d. to 1s. 9d. per light, while for mahogany, walnut or special casings these are somewhere about treble the cost per foot run of ordinary casing. If the casings are painted with three coats of paint, 1s. to 1s. 6d. per light must

be added according to circumstances. With regard to switches, the prices average from 3s. to 3s. 6d., but as a separate switch is not required to every light in the house, a sum of 2s. 6d. per light is sufficient to cover this item; while safety-fuses, distributing-boards, and other sundries may add another 3s. to the total cost per light if the best material be used.

From these figures it will be seen that the cost for average wiring may be said to vary from 23s. to 28s. per light. Where there are special difficulties in construction, and where on account of the decoration and other reasons it is desirable that the best class of labour only is to be employed, or again where the wires are desired of a larger sectional area than the size usually installed in accordance with the Fire Insurance Company's rules, this cost is liable to be increased to as much as 35s. to 40s. per light. In large buildings where the number of lights are great and the runs are long, necessitating special allowances for the main cable, the cost varies from 30s. to 36s. per light on the average, and it may be noted that for wiring the Langham Hotel, some 1450 lights in the best manner, the price *in competition* was 34s. per light.

Insurance.

Electric lighting when well done is the safest of all illuminants, and in this respect differs essentially from oil or gas where, however excellent may be the construction of the apparatus, or however carefully the fittings may be arranged, danger is always inherent to such processes of combustion.

The Fire Insurance Companies have formulated a carefully devised code of regulations with regard to placing and fixing Electric light wires, with other important details.

In an introductory note to these rules Mr. Heaphy, who has had great experience in the subject of Electric wiring,

says, "Remember this, that any firm by arranging to place inferior quality of work in your premises can easily under-price other firms that are more conscientious; and experience proves that inferior work is nearly certain to result in a fire breaking out sooner or later—perhaps between floors and ceilings, or under roofs. Be careful, therefore, previous to accepting a low tender, to make yourself certain that the same quality work has been estimated for and intended to be done as that of the higher tender." Although this has been often quoted, such truth will readily bear mentioning again, as it is essentially in the interest of Electric lighting that the standard of wiring work should be maintained as high as possible.

CHAPTER VII.

THE ARRANGEMENT AND WORKING OF A PRIVATE INSTALLATION.

THE subject of house-wiring for the Electric light having been dealt with in the preceding chapter, a few remarks will not be out of place here with regard to the engine-room part of the installation.

Perhaps it would be as well to discuss those cases in which private installations may prove of advantage.

In the country with gas over 3s. per 1000 feet, or where oil has to be used, entailing as this does the daily cleaning of numbers of oil lamps, separate machinery for producing anything over fifty lights will usually prove advantageous.

Again, even in towns where a public supply is obtainable, it frequently pays to produce one's own Electricity. This is especially so where machinery is already at work, as in printing offices, hotels, factories, &c. Even where machinery is not fixed, provided large numbers of lights are continually in use, a separate installation is often more economical.

It is sometimes desirable in such cases to have the option of obtaining current from the Public Supply Company as well. This particularly applies where the hours of working are so long that a double shift of men would be necessary to work the Electric machinery. For instance, as in the case of some of the large London clubs,

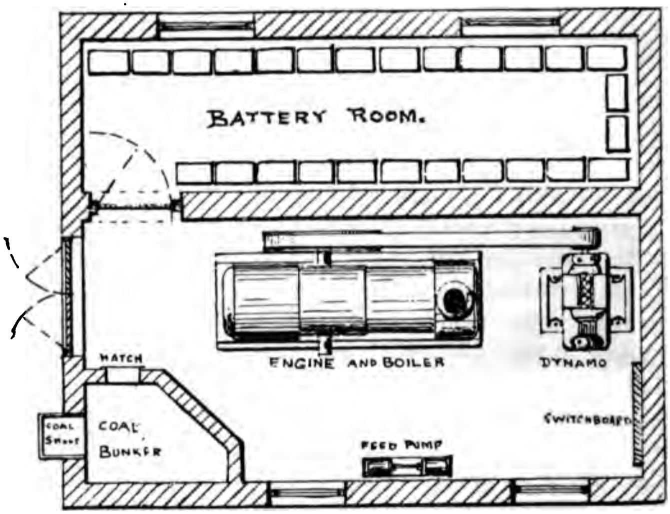
after the private machinery has done its day's (or rather its night's) work, the current from the Supply Company is switched on, and any few lights that may be required during the ensuing twelve hours are so supplied.

When Public Electric Supply Companies were first established, it was generally supposed that all separate installations in their districts would be done away with. This is far from being the case, and in some instances, where the many advantages of Electric lighting have been proved by daily use from a Public Supply Company, separate installations have afterwards been set up. The Public Supply Companies, however, have nothing really to fear in this respect. A large portion of their income is derived from the small consumer with forty lamps or less, and usually large consumers, even if space could be found for machinery, would rather take current by meter than lay out capital on a private installation. Private installations can be of course of any size, from a compact little plant of fifty lights, worked by a gas-engine, to the 3000-light installation at the Savoy Hotel, and which almost ranks as a central station.

When a private installation has once been decided upon, if it be properly arranged and well carried out, the outlay is seldom regretted. The most important consideration is, of course, the question of power. How is the dynamo to be driven?

Gas-engines, of course, have obvious advantages in many cases, more particularly for town houses, as a cellar may often be used for an engine-room. Recent improvements made in the construction of gas-engines render them now capable of driving dynamos for direct supply without any flickering of the light. The interesting calculation given on page 165 shows that a much greater amount of light can be obtained by passing gas through

an engine to produce Electricity from a dynamo than by consuming it direct in gas burners; as a general rule, however, it will be found that steam is the most suitable and economical power for driving the dynamo. Steam power is already employed in most factories, and sometimes also on country estates for pumping, cutting chaff, sawing wood, &c., and in the latter case, where it is not



PLAN OF INSTALLATION FOR 150 LIGHTS.

already in use, it will always be found acceptable for such purposes. In the annexed illustration an engine-room is shown, fitted with steam-engine and dynamo for the supply of 150 lights.

Steam power having been decided upon, the next matter is the choice of an engine-room. An outbuilding *or stable can* often be found, and where possible such a

position is more desirable than the use of a room under or in the main building. A good engine-room should be thoroughly dry and clean, with a solid foundation, and at not too great distance from the house. The illustration given shows a good method of arranging the electrical plant, and includes engine and boiler-room 23 feet by 11 feet, battery-room 23 feet by 6 feet,* coal-bunker, and ash-pit.

Considerable experience is required to satisfactorily plan out a private installation, as the whole number of lights in a house are seldom if ever required to be burning at once. When the engine is too small, troubles will very soon arise, and when too large a needless consumption of coal is entailed.

After the remarks made in Chapter V., on the subject of accumulators, readers will probably agree that no country installation, at all events, is complete without them. In fact, they are so serviceable and convenient, that they can rarely be dispensed with.

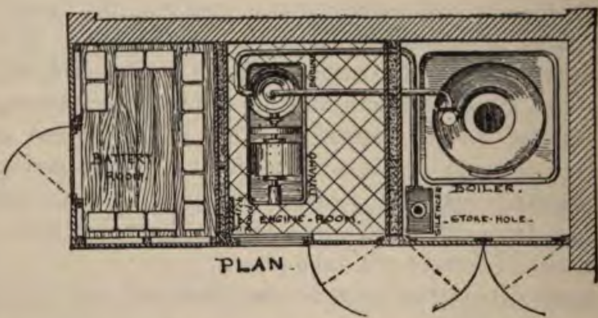
As shown in the illustration, the accumulators are usually placed in a separate room from engine and dynamo. The reason of this is, partly because the slight acid fumes given off during their charging would rust the machinery, and partly because dust and dirt from the coal would interfere with the action of the cells. It will be observed in the illustration on page 55 that each cell is placed on glass insulators, and the whole battery arranged on isolated wooden supports. This is to prevent any leakage to earth of the current from the cells, and also to guard against what is called "creeping," *i.e.*, a surface leakage from cell to cell, by which a slight but wasteful discharge of current will take place.

People often grumble at accumulators and say they are

* It is not at all necessary that the battery-room be of the shape shown, but about an equal amount of floor space is required.

of no use, when, as a matter of fact, the poor accumulator

THE WRITER'S 50-LIGHT INSTALLATION AT WEYBRIDGE.



is being overworked and undercharged. It is false

economy to have accumulators too small for the work they have to perform, and it is much cheaper to have a battery too large than too small.

The dynamo is usually placed in the same straight line with the engine, and is driven by a belt. In the illustration of the writer's plant, which has now been working for several years, a very compact arrangement is shown, the dynamo being connected up direct with the engine and no belt used. In a country installation, when accumulators are employed, the best plan of working usually is to charge them in the afternoon for a few hours, and then continue the working of the engine during part of the evening, when most of the lights are required, so as to supply them direct from the dynamo. Later on, when less lights are used, the engine may be shut down, and the accumulators give off the supply of current required during the rest of the evening and till the next day.

If the plant be properly managed and the accumulators are left well charged, they should be sufficient to supply all the current that is wanted on Sunday. On special occasions, when it may be required to use the whole number of lights for a considerable time—with perhaps even a few extra lights as well—by keeping the dynamo running and discharging the accumulators at the same time, the current-producing power of the installation is largely increased.

The engine-room switch-board should consist of a main-switch for controlling the whole number of lights, and separate switches for either sending the current (*a*) from the dynamo to the lamps, (*b*) from the dynamo to the accumulators, or (*c*) from the accumulators to the lamps. If these switches be distinctly labelled, any one strange to the engine-room may readily control the current in th absence of the attendant. The main safety-fuses and tw

instruments, the ammeter and the voltmeter, complete the arrangement. The former meter is for measuring the *amount* of current passing, the latter its strength or *pressure;* and each instrument should have a "two-way" switch, so that readings can be taken from either the dynamo or the accumulators.

With regard to the working of such an installation, it is not of so much importance that the man looking after it should have any special knowledge of Electricity or mechanics, as that he should be careful and painstaking. Experience has proved that after being shown a few times how to work the machinery and attend to the accumulators, any man with an interest in his work will be able to manage it. A gardener, stable or handy man about an estate is quite capable of doing all that is necessary without retaining a man specially for the work. A few simple, plain instructions should always be kept in the engine-room for his guidance.

For those already possessing Electric light plants or contemplating their erection, the following brief rules for working may prove useful:—

DYNAMO.

Commutator. The commutator should be kept quite clean and bright by wiping it occasionally with rag when working. If necessary it may be cleaned with emery cloth before starting, the brushes being off.

Brushes. The brushes must be set firmly in their holders, and rest lightly on the commutator so as to make good clean contact. They must be set exactly opposite each other, and no wires left straggling.

Sparking. The rocker holding the brushes should be moved up or down, so as to adjust them to the neutral point, according to the amount of work the dynamo is doing. *When properly adjusted there should be no sparking.*

Disconnecting Dynamo. In disconnecting the dynamo after it has been used for charging the accumulators or supplying the lights direct, the engine should be eased down, dynamo switch turned off, the engine stopped, and then the brushes taken off the commutator.

ACCUMULATORS.

Charging. The dynamo must be run at full speed, the brushes on, and the pilot lamp lit to its full candle-power, before the accumulator charging switch is put on. Care should be taken not to allow the speed to drop while charging, or the accumulator will rapidly discharge its current through the dynamo. When the cells are charged the solution will assume a clouded appearance, great numbers of small bubbles continually arising to the surface. It is often thought when the cells gas in this manner that the accumulator must be full, but this effect can be produced by too rapid charging, and it is not until the cells gas *freely* for some time that the accumulator may be considered fully charged. When in good order, the positive plates should be dark chocolate, and the negative a clear slate colour. Before shutting down the engine, turn off the charging switch.

Faulty Cells. If any cell does not gas so freely as the others, it is probably because a connection has been formed in some way between one or more of the positive and negative plates, as for instance by "buckling." Such a cell should be disconnected and examined, the cells on either side of it being connected together by a short piece of cable. A thin piece of wood should be used to scrape off scales that may have formed on the plates of faulty cells.

Acid. The acid solution is in the proportion of five of water to one of acid, the specific gravity being 1·200. *The plates should always be covered over the top with the solution,* and when the battery is fully charged the specific gravity should be 1·215. This is measured by means of an acidometer (or hydrometer), supplied with every set of accumulators.

When not in use. If the accumulators are not in use for any considerable time, they should be left fully charged, and a further charge given them every two or three weeks.

CHAPTER VIII.

THE PUBLIC SUPPLY OF ELECTRICITY.

IT was the invention of the Incandescent Lamp that opened the field of domestic lighting to Electricity, but the problem of *economically* distributing Electric current over large areas in the same way as gas, presented, however, many practical difficulties.

It is an illustration of the distance that Mr. Edison was in advance of other Electricians, that while they were still considering how a public supply of Electricity should be brought about, he had already thought out the whole matter and devised a scheme of Electrical distribution by means of special mains, regulating switches and safety-fuses, all complete in their way. While every one was learning what Electric lighting meant at the Exhibition in Paris, 1879, Mr. Edison was even then arranging the erection of his first central supply station in New York, and although improvements were carried out from time to time, Electricity was supplied from it continuously until the station was burnt down in 1888.

Undoubtedly the Electric Lighting Act of 1882 prevented similar stations being erected in England; but, perhaps, on the whole it is as well that it was so, for much had still to be learned and experience gained before the problem could really be economically dealt with. In America, town after town fitted up central supply stations, so that the general adoption of the Electric light in public

buildings and private houses was soon brought about. As long ago as 1887, over one hundred central stations were at work in the United States, supplying in all close upon half a million lights, and since that time much progress has been made.

America has indeed been our pioneer in the matter of Electric supply. But by patiently watching and waiting we have had all the experience with little of the expense. The result is that to-day we are actually in a more forward condition than they are in America. Benefiting by their evil experience of fixing the supply-cables overhead, we have generally adopted underground systems; and now, when the Americans are beginning to see their mistake, we have the greater portion of London and several provincial towns fitted with complete underground systems of Electric supply.

The Electric Lighting Amendment Act of 1888 at last permitted the advance of Electrical enterprise all through the country. Many who could afford to do so had already adopted the light and fitted up their own separate installations, and in London the Grosvenor Gallery Company were supplying a few customers with current by means of overhead cables, which it was alleged did not come under the Act of 1882. During the last five years much has been done; powers have been granted to a number of public companies both in London and the provinces, and experience, together with keen competition, has brought about several different systems for Electric supply.

Before mentioning the various Supply Companies, the means by which Electricity may be distributed must first be considered. For this purpose the systems may be conveniently classified under the heads of High, Medium, and Low Pressure.

Electric Pressure.

Electricity is so different to steam, water, or gas, that it is at all times difficult to comprehend. But in order to explain its phenomena coherently it often becomes necessary to liken them to effects produced by some other body of a more determinable nature. Thus the "head" or pressure of water flowing in a pipe, forms some analogy to the pressure of Electricity passing through a conductor. Again, water encounters resistance from friction in its flow through the pipe, and the passage of a current of Electricity through a conductor implies also a certain amount of resistance overcome. This resistance can be diminished by increasing the *size* of the conductor, but in the problem of the economical distribution of Electricity, the size and cost of the copper conductors is always an important factor. On the other hand, by *increasing the pressure* of Electricity, smaller cables can be used, in the same way that water at a high pressure does not require such a large pipe to convey it as does water at a low pressure.

The Volt.

As it will be necessary to refer frequently in this chapter to the pressure of Electricity—that is, its Electro-Motive Force (written for short E.M.F.)—it may be well to note that the unit of pressure is called a *volt*. Many people ask what a volt is, how much it is, and so on; but an exact scientific definition (*see Glossary*) conveys but little meaning to many. How many people know exactly what a pound or a pint is? although no doubt they can form a pretty accurate mental picture of their respective amounts. But it is found in all cases that a frequent use of a term conveys in the course of time a very real meaning. So it will be with the volt—the unit of pressure in Electricity. At the same time it should be remembered that the system of Electrical units is based on thorough scientific principles,

which enable the standards of pressure, current, and resistance to be reproduced when required, irrespective of such standards of measurements as three barley-corns to the inch, or the length of the king's foot.

Low Pressure Direct.

As was mentioned in Chapter IV., the Incandescent Lamp is constructed to burn at various pressures, but as yet no durable lamp is manufactured to withstand a higher pressure than 110 volts. The Electrical pressure, therefore, on the lamp mains must not *exceed* this.

In the system of distribution first devised by Mr. Edison, he used a current of 110 volts, so that the lamps might be supplied "Direct" from the dynamo. Low pressure such as this, requires large copper cables, and such a current can only be economically distributed within a short distance from the supply station, otherwise the cost of the copper cables would be very great.

There are many advantages in connection with this system, especially where large quantities of Electricity are used in the immediate neighbourhood of the central station. A modification of the original system has been invented independently by Dr. J. Hopkinson and Mr. Edison, and is known as the "Three-Wire System."

The Three-Wire System consists in connecting up the dynamos and main cables in such a way that a very considerable saving is made in the amount of copper required for the distributing mains. The system is extensively used in America as Edison's system. It has also been successfully employed in London and elsewhere; for instance, by the St. James' Electric Supply Company, whose station is surrounded by clubs and other large buildings, so that a considerable number of lights are supplied in a small and compact area.

Another variation of the low-pressure system of distribution is that in which accumulators are employed as an adjunct. These are usually placed at the station, to act not only as a sponge which can be squeezed when the engines require assistance, but also as regulators, and in addition by supplying the total current when there is least demand for light, they enable the machinery to be shut down and the working expenses of the station to be reduced.

Low Pressure with Accumulators.

Whether the use of accumulators affords a more reliable public supply of Electricity has always been a debatable point, and the question is whether the reserve at a central station should be in the shape of accumulators, or should depend rather upon a proper arrangement of the machinery, so that in the event of a breakdown only one machine is affected. Many engineers affirm their preference for a mechanical and electrical reserve, such as duplicate machinery, rather than a chemical reserve in the form of accumulators.

But it is not proposed, either here or elsewhere, to enter into the economic aspects of the various systems, as this is more a question for the directors to justify to their shareholders.

A serious objection to a low-pressure system is that the central station must be approximately in the centre of the district to be supplied, a position which it is not always possible to obtain; while there are many other objections to so erecting a large central station, with its accompanying noise and nuisance to the neighbourhood. One such station would be required to at least every square mile of the town, for it is impossible to give an economical supply of low-pressure Electricity beyond a certain distance from *the station.*

Again, it will easily be understood that the cost of long lengths of thick copper cables laid in the streets is one of the chief items in the expenditure of an Electric Supply Company, and if these cables can be diminished in size by employing currents of a *higher pressure*, a great saving results. This is the keystone to all questions of Electrical distribution.

Medium and High-Pressure Systems.

The longer the cable, the more resistance there is to the passage of the current, and the thicker the copper needs to be. By using Electricity at a medium pressure—say at 1000 volts—Electric currents can be conveyed by *small* mains for some two or three miles, and with only a slight loss. In many cases much higher pressures than this are employed. Mr. Ferranti devised a high-pressure system for the London Electric Supply Corporation, whereby Electric currents of 10,000 volts pressure are brought all the way from Deptford to Central London, and high-pressure systems of 5000 volts are employed for lighting Rome and many other cities on the Continent. The use of medium or high-pressure currents thus enables Electricity to be economically conveyed a long distance by small copper conductors. But it has been already pointed out that durable incandescent lamps are not at present made to withstand a higher pressure than 110 volts. Therefore, when medium or high-pressure currents are used there must be some device for reducing the pressure before the current enters the house, and for this reason they are known as "transformer systems."

The Transformer.

The question is often asked, "What is a transformer?" and as it will be a matter of interest to many during the next few years, it is desirable to reply at some little length. It has been already explained in Chapter II. that dynamos can be

designed to give off either continuous or what is termed "alternating" Electric currents. It is in connection with transformers that the latter currents have hitherto been found so useful.

THE TRANSFORMER.

The illustration shows a transformer or converter. The mains from the street are connected to the top or high-pressure terminals, while the lamp-wires to the house are attached to the bottom side. Although the two sets of wires within the transformer do not come into Electrical contact, the moment a high-pressure alternating current is passed through the high-pressure Primary wires a current of low-pressure is "induced" in the Secondary or lamp wires.

At each alternation of the high-pressure current the flow of Electricity assumes the form of a wave. Every time these high-pressure alternations or waves take place, Electric waves or currents are "induced" in the neighbouring low-pressure coils. The occurrence of these changes is so rapid that the series of induced currents of Electricity produced in the secondary mains has, as far as Electric lighting is concerned, exactly the same effect as a continuous current. So long as the high-pressure alternating wave current remains steady, the incandescent lamp preserves a constant brilliancy, never for a moment flickering or decreasing its light. It must be remembered, however, that Electric currents are only thus "induced" when the high-pressure current *alternates or waves* and *changes its form*, so that a *con-*

tinuous current is not applicable for such induction purposes.

It will be understood that before the transformer system was brought to its present perfection, a great amount of experience had to be gained in the use of transformers to enable them to be designed so that the right pressure of current is economically induced in the secondary or house wires, and so that it could be properly regulated. Nothing, however, can be simpler than the apparatus as it now is; the high-pressure mains from the street are simply connected to one side of the transformer, while the wires from the house are connected to the other. There is no moving mechanism, and the two sets of wires do not come into Electrical contact, yet Electricity of the desired low pressure is obtained. When one reads of this, it almost seems that with Electricity one has simply to order, and however difficult, and whatever the requirements may be, it is immediately found they can be carried out!

One of the chief reasons for the success the transformer system has achieved is, that it enables a company to light a large area economically under conditions which would be impossible with any other system. The station can be erected at a distance from the district to be lighted, for at a comparatively low cost it is possible to convey Electricity economically any reasonable distance from the station. It is not necessary to wait for a number of people in a street to agree to use the light before the expense of heavy cables is incurred. Small mains can be run to feed only a few transformers, and thus custom for the Electricity is quickly obtained, working expenses paid, and a dividend earned.

The method of supply generally adopted at first, is to place transformers in the consumer's house, and as the

Each of these systems has, of course, its special advantages and disadvantages. The exceptional simplicity and the efficiency of the "Transformer" method of conversion renders the alternate current by far the better system for transmitting and distributing Electric Energy at a high pressure. Unfortunately a serviceable and efficient alternate current Electric motor has not yet been constructed. Again, accumulators cannot be charged by such currents, and continuous currents are also better for the steady working of arc lamps.

It seems, however, probable that the practicable advantages of both may be combined in the future, through the developments now taking place in connection with multiphase currents. (See page 20.)

Such two-phase or multiphase alternate currents have all the advantages of the simple alternate current, and conversion from high to low pressure (or *vice versa*) is effected by the transformer in the same simple and efficient manner.

Recent experimental work has also shown that such two-phase currents can be so arranged in relation to one another on suitable commutators that in a machine analogous to the motor-generator just described, *continuous* currents of any desired pressure can be excited by them.

With such a machine, multiphase alternating currents might be used for high-pressure transmission and distribution, and for which in many respects they are so admirably adapted, and at suitable sub-stations they could be transformed down to either simple *alternate* low-pressure or *continuous* low-pressure currents at will.

These developments belong to quite recent *experimental* work; but if such a system could be really practicable, the advantages of high-pressure would be combined with *all those of the* low-pressure system.

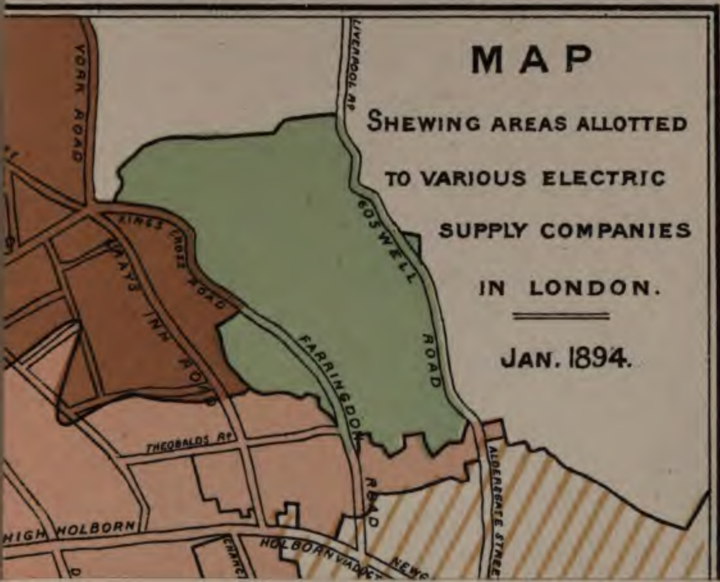
By such a plan Electricity would be generated at one or more large stations some distance away and brought to the sub-stations, from whence the low-pressure supply would be distributed by means of either alternate or continuous currents to the different parts of a city or town. Many Electricians look upon this as likely to be the ultimate solution of the problem of distribution in the future, when nearly every house in a street demands current for light, power, or other purposes, and when the time comes for the erection of large Electric supply stations on the same scale as the huge gas-works around London and provincial towns.

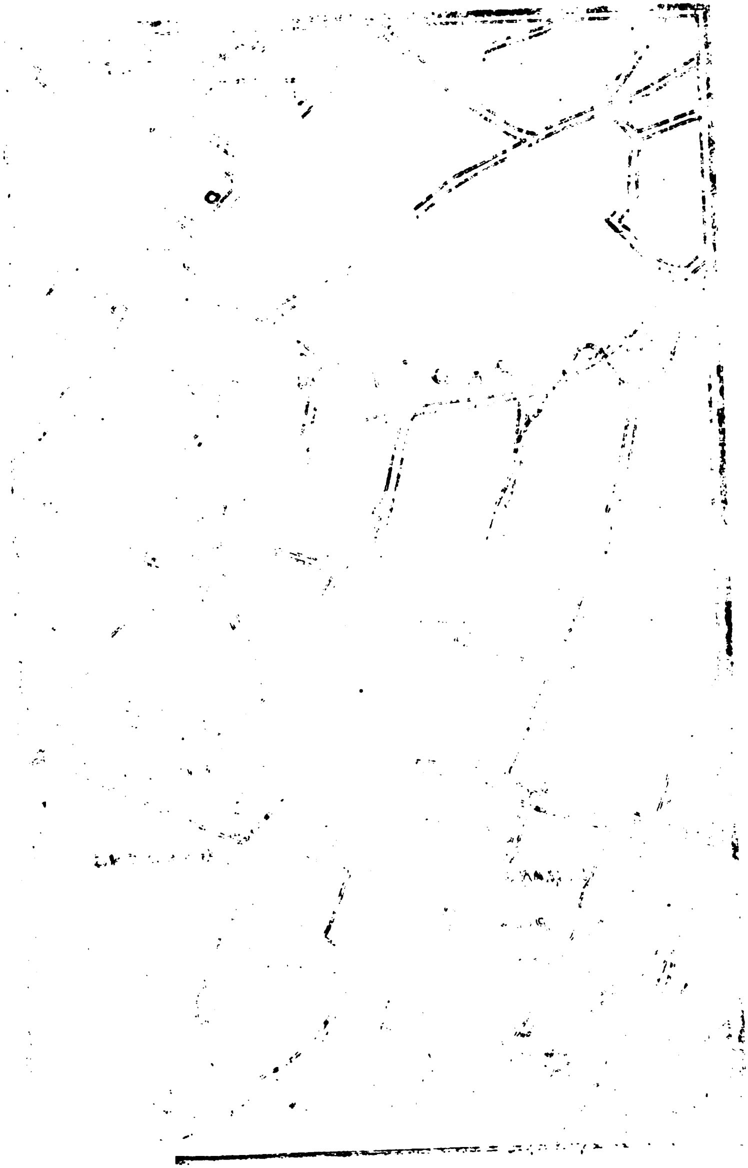
Much has been said and written of the danger of high pressure, but Mr. W. H. Preece, the chief Electrician of the General Post-Office, has remarked that "Electrical engineers are far more able to protect the public from even 50,000 volts than gas engineers are to protect the public from explosions, or ordinary steam engineers from bursting boilers."

The different systems of supply have thus been explained with as little technical detail as is possible for the proper understanding of the subject, and it will be understood that a Battle of the Systems has been going on somewhat similar to the Battle of the Gauges in the early days of railways. In ten years' time considerable alterations will probably have been made in all the systems now employed for distributing Electricity. But it must not be thought from this that the money now being spent by the companies on central supply stations is likely to be lost or that the undertakings are premature. Many of the alterations that will be made in the systems of supply cannot be undertaken until there is a very general demand for current in a district. And whatever the altered arrangements may be in the future, in some instances they can

be carried out at comparatively little expense and w
depreciating the capital value of the work already d

As to the pressure of Electrical supply most suita
existing demands, doubtless many will agree wi
writer that avoiding the low pressure on the one si
the very high pressure on the other, a *medium* p
such as is extensively distributed in London by the
politan Electric Supply Company, may be conside
wisest course to adopt.


MAP
SHEWING AREAS ALLOTTED
TO VARIOUS ELECTRIC
SUPPLY COMPANIES
IN LONDON.
JAN. 1894.
YORK ROAD
LIVERPOOL RD
GOSWELL ROAD
KINGS CROSS ROAD
GRAYS INN ROAD
FARRINGDON ROAD
THEOBALDS RD
HIGH HOLBORN
HOLBORN VIADUCT
ALDERSGATE STREET



CHAPTER IX.

THE PUBLIC SUPPLY COMPANIES.

THE passing of the Electric Light Amendment Act of 1888 was the signal for numberless applications for Provisional Orders for the supply of Electricity. The issues involved were of such importance that the Board of Trade appointed Major Marindin to hold a public inquiry into the different applications and the various systems proposed to be employed.

In the more favoured London districts, for which several applications had been made, the Board of Trade decided to grant *concurrent* powers to two companies, but working opposing systems, so that in St. James', Piccadilly, for instance, the consumer has the choice between a low and a high-pressure system of supply.

Where there is a large demand for Electricity two companies can profitably work side by side, and such competition is for the public benefit. Such a plan would, however, defeat its object in the less favoured districts, as, even if capital could be obtained for companies to work under such conditions, only one could succeed, and sooner or later the other would go to the wall. In London the Board of Trade permit a maximum of 8d. per unit (see page 157) to be charged for Electrical Energy. Where a company with *sole* powers for a district does its work well, and charges less than the maximum (say 7½d.), the local authority and the Board of Trade should seriously consider

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what, if any, advantage could be gained by admitting another and speculative company.

Continual interference with our roads and streets, which are already crowded with pipes, would be a serious public inconvenience, and certainly investors would do well to carefully inquire into the conditions of working and especially the competition to be anticipated, before they support the promotion of any new competitive Electric Supply Companies.

It is now proposed to briefly summarise the companies engaged in the public supply of Electricity under Parliamentary Powers in London and the Provincial towns. The figures given are in all cases up to November 1893, and these, as well as the statements made, have been verified by application, so far as possible, to the companies themselves. The prices for Electrical Energy are per Board of Trade Unit (B.T.U.)

HIGH-PRESSURE SYSTEM.

The London Electric Supply Corporation, Ltd.

Secretary's Office, 3 ADELPHI TERRACE.
CAPITAL, £1,250,000, consisting of
200,000 £5 Ordinary ; £555,000 subscribed.
50,000 £5 6 per cent. Preference ; all subscribed.
£80,000 5 per cent. Debentures.

Quotations since January 1st, 1893—	Highest.	Lowest.
£5 Ordinary	$1\frac{1}{8}$–$1\frac{3}{8}$	$\frac{3}{4}$–1
£5 Preference	$2\frac{1}{4}$–$2\frac{3}{4}$	$1\frac{1}{4}$–$1\frac{3}{4}$

Dividend paid 1890, 6 per cent.

Chairman . . MR. JAMES STAATS FORBES.

Chairman until recently was Lord Crawford, whose scientific attainments are well known. Since Lord Crawford's retirement from ill-health, Mr. J. S. Forbes, Chairman of the L. C. & D. Ry., occupies this position.)

This Corporation has at present *sole* powers in the Parishes of Rotherhithe, Bermondsey, Clerkenwell, St. Mary's, Newington, Camberwell, St. George the Martyr, St. Olave's and parts of Southwark, Greenwich, and Lambeth; *concurrent* powers with the Westminster E. S. Co. in the Parishes of St. Margaret's and St. John's, Westminster, and St. George's, Hanover Square; with the Chelsea E. S. Co. over part of the Parish of Chelsea; with the St. James' and Pall Mall E. S. Co., in the Parish of St. James', Westminster, and with the Charing Cross and Strand Electricity Supply Corporation in part of St. Martin-in-the-Fields.

Charge for Electric Energy, 6d. per B.T.U.

Length of Mains laid, 70 miles.

Lamps connected, 65,000 Incandescent and 95 Arc.

The L. E. S. Corptn. has the distinction of being the pioneer in the public supply of Electricity, and is worthy of something more than a brief mention. Originally known as the Grosvenor Gallery Electric Supply Company, it began work by supplying light to the Grosvenor Picture Gallery and Library in Bond Street, from a station in the basement of that building. After a time, the light being found to work satisfactorily, a number of buildings in the neighbourhood had connections made by means of overhead cables, and the Grosvenor Gallery Company soon became the centre of a small system of Electric supply. The demand for light continually increased, and a number of large houses about Mayfair and Hyde Park were included, until in 1888—the year of the Amendment of the Electric Lighting Act—it was found impossible to supply more lights, the machinery being already overloaded.

From the encouragement accorded their efforts at the Grosvenor Gallery station, the Directors considered the supply of Electric light might be successfully undertaken on a large scale. The light was popular, and they clearly saw that in the near future the demand for it would increase with great rapidity. The old company was con

verted into the London Electric Supply Corporation, and a new station of colossal dimensions was erected at Deptford on entirely new lines. Machinery for 250,000 lights has been already erected, and alternating currents of 10,000 volts are employed.

This high-pressure current is conveyed from Deptford by trunk mains to what are called "Transformer Stations," one of which is at the Grosvenor Gallery, and others at Adelphi Terrace, Trafalgar Square, Belgrave Mansions, Blackfriars Road, and Deptford. Here transformers are fixed, by which the current is converted from 10,000 to 2500 volts, and this latter pressure, on reaching the house-transformer, is in its turn converted to 100 volts, being the pressure at which the lamps burn. Though there is a certain percentage of current lost in conversion through each transformer, and therefore a double loss by double conversion, the Corporation claim that they are amply repaid for this loss by the many advantages gained in the position of their station. Space at Deptford is less limited than in Central London; and, moreover, being on the river-side, they are enabled to get the very large supplies of coal required direct from the steamers, and therefore at a reduced cost. It is urged that a concern of the same size as the Deptford station when in full working order could not be erected nearer London, on account of the nuisance caused by so much machinery and the higher price of land.

The trunk mains bringing the high-pressure current from the dynamos at Deptford to the transformer stations are now brought underground all the way, and are well insulated and sheathed in lead.

The Metropolitan Electric Supply Company, Ltd.

Secretary's Office, WINCHESTER HOUSE, E.C.
. CAPITAL, £500,000, consisting of
49,900 £10 Ordinary; all subscribed.
100 £10 Founders'; all subscribed.
£100,000 5 per cent. Debentures; 50,000 issued.

Quotations since January 1st, 1893—	Highest.	Lowest.
£10 Ordinary	$8\frac{1}{4}$–$8\frac{1}{2}$	$6\frac{1}{4}$–$6\frac{1}{2}$
£10 Founders'	100–130	80–100
£5 per cent. Debentures (1902) . .	104–106	101–3 x d

Dividends paid—1891, 1 per cent.; 1892, 2 per cent.

Chairman . . . SIR JOHN PENDER, G.C.M.G.
Engineer-in-Chief . MR. F. BAILEY.

(Sir John Pender is already well known in connection with Electrical matters, from the prominent part he has taken in the successful development of submarine telegraphy throughout the world.)

The important and extensive areas originally granted to this Company have been further increased by the addition in 1890 of the Paddington district. It has at present *sole* powers in Holborn, Bloomsbury, St. Giles', Lincoln's-Inn-Fields, Marylebone, Paddington, and the Strand district; and *concurrent* powers with the Charing Cross and Strand Electricity Supply Corporation over part of St. Martin-in-the-Fields.

Charge for Electric Energy, $7\frac{1}{2}$ per B.T.U., subject to sliding scale. A reduced rate is offered for Electric cooking purposes.

Length of Mains laid, 222 miles in 70 miles of pipe.

Lamps connected, about 163,000.

The plan of operation at present embraces five central stations, one of which, at Whitehall, is on the low-pressure system, the supply from it being mainly taken up by the large buildings in its immediate neighbourhood. The four large stations are at Sardinia Street, Lincoln's-Inn-Fields; Rathbone Place, Oxford Street; South Street, Manchester Square; and St. Peter's Wharf, Paddington. The capacity of each one of these stations is alone equal to the total capacity of some of the other London

Supply Companies. All four stations are connected together by trunk mains, so that one station can at any time assist another in the event of partial disablement; or can furnish the whole supply of two stations during the hours of least demand.

This is considered preferable to one central undertaking, and by establishing a number of self-contained stations the Metropolitan Electric Supply Company are able to use alternating currents of comparatively low pressure, viz., 1000 volts. This is reduced by transformers fixed in the houses of consumers or in substations. Mains, highly insulated with vulcanised rubber, are laid in cast-iron pipes, with brick manholes at intervals, into which new cables can be drawn or repairs done without the expense of interfering with the roads. The Metropolitan Electric Supply Company, which has a lamp connection greatly in excess of any other supply company, has been very regular in the supply of current to its consumers, and undoubtedly has a great future before it.

The City of London Electric Lighting Company, Ltd.

Secretary's Office, 1 and 2 Great Winchester Street, E.C.
Capital, £800,000, consisting of
40,000 £10 Ordinary; all subscribed.
40,000 £10 Preference; £200,000 issued.

Quotations since January 1st, 1893—	Highest.	Lowest.
£10 Ordinary	$12\frac{5}{8}$–$12\frac{7}{8}$	$10\frac{1}{2}$–$10\frac{3}{4}$
£10 Preference	$12\frac{3}{4}$–$13\frac{1}{4}$	$12\frac{3}{8}$–$12\frac{5}{8}$

Dividend paid—1892, 6 per cent.

Chairman . . . . Sir DAVID SALOMONS, Bart.
Engineer and Manager . . Mr. DAVID COOK.

(Sir D. Salomons is well known not only for his book on the Management of Accumulators, but also for the active interest he has taken for a long time in all Electrical matters.)

This Company has at present *sole* powers over the entire City proper from Temple Bar to Tower Hill, and from Smithfield Market to the Thames. The system employed is a medium-pressure distribution at 2000 volts, the current being continuous in the case of the street arc lamps, and alternating with transformer stations for the supply of incandescent lamps.

Charge for Electric Energy, 8d. per B.T.U., subject to a sliding scale in accordance with the agreement made with the City authorities. A reduced rate of 4d. is offered for cooking or motive power.

Length of Mains laid, about 90 miles.

Lamps connected equivalent to 60,000 8 c.-p., and 490 of the 500 Arcs for the public lighting of the City.

The House-to-House Electric Supply Company, Ltd.

Secretary's Office, Richmond Road, Kensington.

Capital, £350,000, consisting of

57,900 £5 Ordinary; £41,610 subscribed.

15,000 £5 7 per cent. Preference cumulative; £24,830 subscribed.

100 £5 Founders'; all subscribed.

300 £100 6 per cent. Debentures; all subscribed.

Quotations since January 1st, 1893—	Highest.	Lowest.
Ordinary £5 shares	$1\frac{1}{2}$–$2\frac{1}{2}$	1–2
7 per cent. Convert. Pref.	$5\frac{1}{4}$–$5\frac{1}{2}$	$4\frac{3}{4}$–$5\frac{1}{4}$
6 per cent. Debentures	97–102	97–100

Dividends paid—1891, 7 per cent.; 1892, 7 per cent.

Chairman . . . . . Mr. H. R. BEETON.

(Mr. Robert Hammond has been chiefly identified with this Company, which was formed in February, 1888.)

At present *sole* powers are possessed over various portions of the large Parish of St. Mary Abbotts, Kensington.

The station is in Richmond Road, and the alternating current generated is of 2000 volts pressure, reduced by transformers fixed in consumers' houses.

Charge for Electric Energy, 8d. per B.T.U., subject to discounts.

Length of Mains laid, 26 miles.

Lamps connected, 26,000.

The Chelsea Electricity Supply Company, Ltd.

Secretary's Office, Draycott Place, Chelsea.
Capital, £100,500, consisting of
14,000 £5 Ordinary; £51,385 subscribed.
6000 £5 6 per cent. Preference; not issued.
500 £1 Founders'; all subscribed.
300 £100 6 per cent. 1st Mortgage Debentures; all subscribed.
200 £100 6 per cent. Debentures; £6900 subscribed.
Dividend paid—1892, 2½ per cent.

Chairman . . Mr. J. IRVING COURTENAY.

This Company has *concurrent* powers with the L. E. S. Corptn. over the whole of the Parish of Chelsea (but the L. E. S. Corptn. are prevented by an agreement from seeking to supply a portion of the Parish).

The Chelsea E. S. Co. has been included under the medium-pressure division, although its system is in its way unique. The generating stations are in Draycott Place and Manor Street, and the continuous currents of 500 volts are reduced by means of a motor-generator (see page 93), in connection with accumulators, at sub-stations, the current being distributed to consumers on a network of mains at low pressure.

At first this reduction of pressure to the house-supply of 100 volts was accomplished entirely by means of sets of accumulators coupled up as mentioned in the last chapter, and erected at three sub-stations. Now the motor-generator, as a simpler and more economical method, is used during the period of maximum demand for current, the accumulators being employed as usual for the remainder of the twenty-four hours; and during the period of least demand the machinery is entirely shut down. It is desirable to add that this system, the economy of which has often been viewed with doubt, has proved commercially successful.

Charge for Electric Energy, 8d. per B.T.U.

Length of Mains, about 20 miles.

Lamps connected, about 40,000 Incandescent and 4 Arcs.

LOW-PRESSURE SYSTEMS.

The St. James' and Pall Mall Electric Light Company, Ltd.

Secretary's Office, CARNABY STREET, GOLDEN SQUARE, W.
CAPITAL, £200,000, consisting of
19,980 £5 Ordinary ; all subscribed.
20,000 £5 7 per cent. Preference ; all subscribed.
100 £1 Founders' ; all subscribed.

Quotations since January 1st, 1893—	Highest.	Lowest.
£5 Ordinary	$8\frac{1}{4}$–$8\frac{1}{2}$	6–$6\frac{1}{2}$
£5 Preference	$8\frac{3}{4}$–$8\frac{5}{8}$	$7\frac{7}{8}$–$8\frac{1}{8}$
Founders'	200–250	150–200

Dividends paid—
Ordinary £5, 1890, 5 p.c. ; 1891, $8\frac{1}{2}$ p.c. ; 1892, $7\frac{1}{4}$ p.c.
Preference 1891, 7 p.c. ; 1892, 7 p.c. ; 1893, 7 p.c. for half year.
Founders', 1891, £10 15s. ; 1892, £3 3s.

Chairman . . . MR. E. J. A. BALFOUR.

This Company has *concurrent* powers with the London E. S. Corptn. Ltd., for St. James', Westminster.

This Company's area of supply, comprising that province recognised as "Clubland," and including Regent Street, Piccadilly, and a portion of the southern side of Oxford Street, possesses unique advantages for the profitable supply of Electrical Energy.

Its station at Mason's Yard, St. James', has now been in operation nearly five years, and a second station has just been completed in Carnaby Street, Golden Square, the two stations being connected together by means of a trunk main.

As the area supplied is not an extensive one, although the demand for current is very great, the district may be termed extremely suitable for the low-pressure three-wire system which is employed ; and now that the Company have generating stations in the northern and southern sections of the Parish, easy facilities are

offered for the ready supply to any point within the boundary lines.

Charge for Electric Energy, 6d. per B.T.U.

Length of Mains, 8 miles.

Lamps connected, 53,000 Incandescent and 55 Arcs.

The St. Pancras Vestry.

Offices, VESTRY HALL, PANCRAS ROAD.

Chief Clerk . . . MR. A. E. PYCRAFT.

The Regent's Park station, near the junction of Euston Road and Hampstead Road, is now complete, and is the first of four that will be ultimately required for this Parish. The three-wire system is employed, and current thus distributed direct to consumers' houses. The public supply commenced on 9th November 1891.

The St. Pancras Vestry is the only Vestry in the metropolis that has retained the Electric supply in its own hands under the Provisional Order of 1883, and therefore unusual interest attaches to the experiment. The cost, so far, has been about £90,000, and the rates have been mortgaged as security for this sum, but no special rate has been levied.

The Vestry is being ably advised by Professor Robinson, and is fortunate in another respect in having such an active interest taken in the scheme by the Vestry Clerk, Mr. Eccleston Gibb.

Although in the future, all gas, water, and kindred undertakings will doubtless be owned and worked by Municipal Corporations, London, from its huge and varied area, will always present problems different from smaller cities. Although the supply given is excellent, St. Pancras can hardly be termed a self-contained parish, as its boundaries run in and out of other parishes. If, therefore, each local authority, as London is at present constituted, were to set up its own public undertakings, the metropolis of the world would soon present a very anomalous state of affairs.

The charge for Electric Energy is 6d. per B.T.U., and a reduced rate, viz., 3d. per B.T.U. for Electricity used for motive power during the *day time.*

The length of mains laid for public lighting is about 8 miles, supplying the 94 Arc lamps now erected for the lighting of Tottenham Court Road, Euston Road, Hampstead Road, High Street, Camden Road, and Park Street; and for the private lighting 6½ *miles, to which* are already connected 12,400 Incandescent lamps.

The Charing Cross and Strand Electricity Supply Corporation, Ltd.

Secretary's Office, 12 Maiden Lane, W.C.
Capital, £150,000, consisting of
30,000 £5 Ordinary; all subscribed.
£70,000 Debentures; £57,400 issued.

Quotations since January 1st, 1893—	Highest.	Lowest.
£5 Ordinary	5–5½	4¾–5¼
Debentures (1900)	100–103	100–101

Dividends paid—1892, 5 per cent.; 1893, 5 per cent. Interim.

This Company has *concurrent* powers with the L. E. S. Corpn., and the M. E. S. Co. over the Parish of St. Martin-in-the-Fields. The station in Maiden Lane was originally erected by Messrs. Gatti to light their Adelphi Theatre and Adelaide Restaurant, but soon afterwards Parliamentary powers were obtained, the station considerably enlarged and the supply extended to the immediate neighbourhood. The three-wire system has been adopted by the Corporation.

Charge for Electric Energy, 6d. per B.T.U.; sliding scale to 5d. per B.T.U.

Length of Mains laid, about 18 miles.

Lamps connected, 34,000 8 c.-p. Incandescent and 49 Arcs.

The Kensington and Knightsbridge Electric Light Company, Ltd.

Secretary's Office, 148 Brompton Road, S.W.
Capital, £350,000, consisting of
50,000 £5 Ordinary; £75,000 subscribed.
10,000 £5 6 per cent. First Preference; all subscribed.
10,000 £5 6 per cent. Second Preference; 1452 issued.
455 £100 4½ per cent. Debentures; all subscribed.

Quotations since January 1st, 1893—	Highest.	Lowest.
£5 Ordinary	5¾–6¼	4¾–5¼
6 per cent. Preference	6¾–7¼	6–6½
4½ per cent. Debentures	100–104	97–102

Dividends paid—£5 Ordinary, 1891, 2 per cent.; 1892, 4 per cent.; 1893, 4 per cent.

Chairman . . . . Mr. GRANVILLE RYDER.

This Company has at present *sole* powers in part of the large Parish of St. Mary Abbotts, Kensington, and part of St. Margaret's, Westminster.

Originally known as the Kensington Court E. L. Co., it was one of the earliest to supply Electricity (1887) to houses on the estate from which it took its name. The Company now have two stations —at Kensington Court, and Chapel Place, Knightsbridge—and a new battery station near Queen's Gate. The distributing mains consist of *bare copper strips* supported on insulators, and chiefly placed in brick conduits under the pavement. This system, although at one time severely criticised, has proved satisfactory, and several miles are laid in this manner throughout the district.

Charge for Electric Energy, 8d. per B.T.U.

Length of Mains laid, 13 miles.

Lamps connected, 61,322.

The Westminster Electric Supply Corporation, Ltd.

Offices, ECCLESTON PLACE, BELGRAVIA, S.W.

Capital, £300,000, consisting of

60,000 £5 Ordinary ; all subscribed.

294 £100 5 per cent. Debentures ; all subscribed.

406 £100 4½ per cent. Debentures ; all subscribed.

Quotations since January 1st, 1893—	Highest.	Lowest.
£5 Ordinary	5½–6	4¾–5¼

Dividends paid—1892, 3½ per cent. ; 1893, 3 per cent. Interim.

Chairman	LORD SUFFIELD, K.C.B.
General Manager . . .	CAPTAIN E. I. BAX.

This Corporation has *sole* powers over part of Westminster, and *concurrent* powers with the L. E. S. Corptn. over the greater portion of Westminster, and part of St. George's, Hanover Square. The central stations are Eccleston Place, S.W., Millbank St., S.W., and Davies St., W. This Corporation is reputed for its steady and uniform service, and is the second largest of the Metropolitan Supply Companies.

Charge for Electric Energy, 6d. per B.T.U. for lighting and 5d. per B.T.U. for motive power.

Lamps connected, 126,086 8 c.-p.

The Notting Hill Electric Supply Company, Ltd.

Offices, Bulmer Place, High Street, Notting Hill.
Capital, £100,000, consisting of
6452 £10 Ordinary ; all subscribed.
2998 Ordinary Preference 6 per cent. cumulative ;
£8,460 subscribed.
550 £10 Founders' ; all subscribed.

Quotations since January 1st, 1893—	Highest.	Lowest.
£10 Ordinary	$5\frac{3}{4}$–$6\frac{1}{4}$	$4\frac{1}{2}$–$5\frac{1}{2}$
6 per cent. Cumulative Preference . .	9–10	
Founders'	10–20	

Chairman . . . Professor CROOKES, F.R.S.

The Company has at present *sole* powers for part of St. Mary Abbotts, Kensington, including the districts of Holland Park, Campden Hill, and Kensington Park. The system employed is the same as the Kensington and Knightsbridge.

Charge for Electric Energy, 8d. per B.T.U.

Length of Mains laid, about 9 miles.

Lamps connected, 10,500 Incandescent and 6 Arcs.

CHAPTER X.

PROVINCIAL ELECTRIC SUPPLY COMPANIES.

City of Bath Electric Lighting and Engineering Company, Ltd.

Offices, DORCHESTER STREET, BATH.

This Company commenced lighting in June 1890, and in 1891 obtained a contract for a period of seven years. The systems employed are the Thomson-Houston for street lighting and Brush alternating for private lighting. The capacity of the station is 10,000 16 candle-power Incandescent and 200 Arcs. The mains are all laid underground.

Charge for Electric Energy, 6d. per B.T.U. Gas is 2s. 8d. per 1000 cubic feet.

Length of Mains, about 65 miles.

Lamps connected, 7000 16 c.-p. Incandescent for private and 84 Arcs for street lighting.

The Birmingham Electric Supply Company, Ltd.

Offices, 14 DALE END, BIRMINGHAM.

CAPITAL, £100,000, consisting of

10,000 £5 Ordinary ; fully subscribed.

10,000 £5 Ordinary ; £20,000 subscribed.

Quotation since January 1st, 1893 . . 5½–6

Dividend paid 1892 . . . . . . 3½ per cent.

Managing Director . . MR. J. C. VAUDREY, M.I.C.E.

This Company has, at present, sole powers in Birmingham, and the low-pressure system is employed.

The supply of Electric light given by this Company has afforded general satisfaction, and, with the assent of the Corporation, it is

their intention to extend their Parliamentary area. In the wealthy residential suburbs of Birmingham, Electric Energy will find a ready sale for lighting purposes; while in many portions of the city, among the small master-workmen, a supply of Electricity, at a reduced rate in the daytime for motive power, will be a great boon.

Charge for Electric Energy, 8d. per B.T.U. Gas is 2s. 7d. per 1000 cubic feet.

Length of Mains, about 5 miles.

Lamps connected equivalent to 20,000 8 c.-p. Incandescent and 94 Arcs.

The Bournemouth and District Electric Supply Company, Ltd.

Secretary's Office, OBSERVER CHAMBERS, ALBERT ROAD, BOURNEMOUTH.

CAPITAL, £50,000, consisting of

10,000 £5 Ordinary; £28,625 subscribed.

Dividends paid—1891, 5 per cent. (for 7 months); 1892, 5 per cent.

Chairman . . . . MR. A. H. SANDERSON.

The present Company was formed to take over the central station started in 1889 by the Brush Electrical Engineering Company of London, under a Provisional Order for the Electric lighting of Bournemouth. The system employed is the medium-pressure alternate current reduced by transformers in consumers' houses.

Charge for Electric Energy, 8d. per B.T.U. Gas is 3s. 6d. per 1000 cubic feet.

Lamps connected are equal to 9250 8 c.-p. Incandescent, and Arc lamps equal to 14,000 c.-p.

Bradford Electric Lighting.

The Bradford Corporation are supplying Electrical Energy under a Provisional Order, and have erected a central supply station on the low-pressure system, upon a site owned by the Corporation near the centre of the town.

Charge for Electric Energy, 5d. per B.T.U. for lighting and 4½d. per B.T.U. for motive power. Gas is 2s. 3d. per 1000 cubic feet.

Length of Mains laid, 19 miles, armoured cables.

Lamps connected equivalent to 11,000 8 c.-p.

Brighton Electric Lighting.

The Brighton Corporation have erected a central station in North Road, Brighton, for the supply of Electricity on the low-pressure system.

Charge for Electric Energy, 7d. per B.T.U. Gas is 2s. 9d. per 1000 cubic feet.

Length of Mains, 9 miles, armoured cables.

Lamps connected, 16,100 8 c.-p. and 40 Arc lamps for public lighting.

The Brighton and Hove Electric Light Company, Ltd.

Offices, Gloucester Road, Brighton.

Capital, £100,000, consisting of

20,000 £5 Ordinary ; £15,000 subscribed.

£15,000 £6 per cent. Debentures ; £7,700 subscribed.

Quotation since January 1st, 1893 4–5

£100 6 per cent. Debentures 100–102½

Dividends paid—1886, 4 per cent. ; 1887, 5 per cent. ; 1888, 5 per cent. ; 1890, 5 per cent. ; 1891, 4 per cent.

Chairman . . . . Mr. ROBERT HAMMOND.

Concurrent powers are possessed over Brighton with the Brighton Corporation. This Company is one of the oldest in existence, having supplied current since 1881. The system employed is the medium-pressure alternate current system with transformers.

Charge for Electric Energy, 7d. per B.T.U. Gas is 2s. 9d. per 1000 cubic feet.

Length of Mains laid, 16 miles.

Lamps connected, 17,000 8 c.-p.

(See also Hove Electric Lighting Company, Ltd.)

Cambridge Electric Supply Company, Ltd.

Offices, 2 Sidney Street, Cambridge.

Capital, £50,000, consisting of

5000 £10 Ordinary ; £17,310 subscribed.

Chairman . . Mr. GERARD B. FINCH, M.A.

This Company has sole powers in Cambridge. The station in *Thompson's Lane* is now complete, and commenced supplying

current in November 1892. The system employed is a medium-pressure alternate current of 2000 volts, with sub-stations and transformers on consumers' premises.

Charge for Electric Energy, 7d. per. B.T.U.

Lamps connected, 7500 8 c.-p.

Chelmsford Electric Lighting Company, Ltd.

Offices, Arc Works, Chelmsford.
Capital, £10,000, consisting of
2500 £1 Ordinary ; £2387 subscribed.
7500 £1 Preference ; £5507 subscribed.
Debentures, £5000, 6 per cent.

Directors . Messrs. R. E. CROMPTON and J. F. ALBRIGHT.

This Company is working under a License from the Board of Trade, and has sole powers in Chemsford. Electricity is generated in the works of Messrs. Crompton & Co., Ltd. The supply is on the alternating current system, the pressure of 2000 volts being reduced by transformers to 110 volts for street circuits and 100 volts for private consumers. The transformers for the street lighting are attached to poles, those for private lighting are banked together in small sub-stations. The wiring is principally overhead, fixed to poles on the pavements ; but in the centre of the town and at many crossings the cables are placed underground in bitumen or other casings. The street lighting was commenced April 14th, 1890.

Charge for Electric Energy is on a sliding scale, averaging 6½d. per B.T.U Gas is 4s. 6d. per 1000 cubic feet.

Lamps connected, 2000 Incandescent for private consumers, 230 32 c.-p. and 21 Arcs for street supply.

The Crystal Palace District Electric Supply Company, Ltd.

Offices, Springfield Works, Wells Road, Upper Sydenham.
Capital, £100,000 in £1 shares ; £28,586 subscribed.

The system employed is the high-tension continuous current with transformers at sub-stations.

Charge for Electric Energy, 8d. per B.T.U. Gas is 2s. 9d. per 1000 cubic feet.

Length of Mains, about 55 miles in 9 miles of trenches.

Lamps connected, about 5000 8 c.-p.

Dublin.

The Corporation have erected a central station at a cost of £31,000, capable of supplying current for 10,000 8 candle-power lamps. Power is generated by three 350 horse-power and three 750 horse-power compound steam-engines, and current supplied on the high-tension alternating system reduced by transformers for incandescent lighting. A direct current system is also employed for public street lighting.

Charge for Electric Energy, 7d. per B.T.U. Gas is 3s. per 1000 cubic feet.

Mains laid, about 20 miles underground.

Lamps connected, 1200 16 c.-p. Incandescent for private, and 80 Arcs for street lighting.

Dundee Electric Lighting.

The Dundee Commissioners (although the owners of the gasworks) have erected a central station for the supply of Electric Energy. The machinery is capable of supplying current for 5000 16 candle-power lamps. The system employed is the low-tension three-wire system, and the mains are of bare copper strips, laid in concrete culverts.

Charge for Electric Energy, 5d. per B.T.U. Gas is 3s. 4d. per 1000 cubic feet.

Lamps connected, 9000 8 c.-p. Incandescent and 20 Arcs.

The Eastbourne Electric Lighting Company, Ltd.

Secretary's Office, Grove Road Chambers, Eastbourne.

Capital, £60,000, consisting of

5000 £10 Ordinary ; £10,170 subscribed.

1000 £10 Preference ; £400 subscribed.

£25,000 £5 per cent. First Mortgage Debentures.

Quotations—£10 Preference, 8–9 ; £100 Debentures, 95–100.

Dividend paid 1892, 3 per cent.

Chairman . . Alderman G. BOULTON.

The system employed is the alternate current medium-pressure, reduced by transformers in consumers' houses.

Charge for Electric Energy, 9d. per B.T.U. Gas is 3s. 2d. per 1000 cubic feet.

Length of Mains, about 9 miles.

Lamps connected, 10,000 Incandescent for private lighting, and 25 Arcs for public lighting.

The Exeter Electric Light Company, Ltd.

Secretary's Office, Rockfield, New North Road, Exeter.

Capital, £20,000, consisting of

1500 £10 Ordinary ; £10,900 subscribed.

10 £10 Founders' ; all subscribed.

500 "A" shares of £10 ; £300 subscribed.

£11,000 5 per cent. Debentures ; all subscribed.

The Company has at present sole powers in Exeter under Provisional Order. The system employed is the medium-pressure alternate current reduced by transformers in consumers' houses.

Charge for Electric Energy, 6d. per B.T.U. Gas is 3s. 1d. per 1000 cubic feet.

Length of Mains (Concentric cable), about 9 miles.

Lamps connected, 5000 10 c.-p. Incandescent and 35 Arcs.

Fareham Electric Light Company, Ltd.

Secretary's Office, Gosport Road, Fareham.

Capital, £5000, consisting of

5000 £1 Ordinary ; £4158 subscribed.

£3500 £5 per cent. Debentures ; £2600 subscribed.

This small Company has been successfully lighting Fareham since September, 1890, by a number of arc and incandescent lamps, but the number of lamps installed for private consumers is, however, at present very small. The system employed is the medium-pressure alternate current system with transformers.

Charge for Electric Energy, 8d. per B.T.U. Gas is 3s. 9d. per 1000 cubic feet.

Length of Mains, about 16 miles.

The number of lamps connected are 21 Arc and 98 20 c.-p. Incandescent for public lighting, and about 400 16 c.-p. Incandescent f private lighting.

The Galway Electric Company.

NEWTOWNSMYTH, GALWAY.

Under a Provisional Order this Company commenced to supply current in 1890. Water-power is obtained from Lough Corrib, and two "Hercules" turbines are employed for driving the dynamos. The low-pressure system with storage batteries is employed.

Charge for Electric Energy, 5d. per B.T.U. for lighting, and 3d. per B.T.U. for motive-power during the daytime. Gas is 5s. 9d. per 1000 cubic feet.

Length of Mains, about 4 miles, part underground, and part overhead.

Lamps connected, 1700 8 c.-p. for private lighting, and 5 Arcs for dock lighting.

The Halifax Mutual Electric Light and Power Company, Ltd.

Secretary's Office, SQUARE ROAD, HALIFAX.

CAPITAL, £20,000, consisting of

4000 £5 Ordinary; £4,551 subscribed.

Quoted since January 1st, 1893 . . . . 4½–5.

Dividend paid 1890 . . . . . . 5 per cent.

The low-pressure system is employed.

Charge for Electric Energy, 8d. per B.T.U. Gas is 2s. 2d. per 1000 cubic feet.

Length of Mains (overhead), 10 miles.

Lamps connected, 400 16 c.-p. Incandescent and 80 2000 c.-p. Arcs.

Hastings and St. Leonards-on-Sea Electric Light Company, Ltd.

Offices, 20 SOUTH TERRACE, EARL STREET, HASTINGS.

CAPITAL, £50,000, consisting of

1657 £10 Ordinary; all subscribed.

167 £25 5 per cent. Debentures; all subscribed.

Quotations 9–10

Dividends paid—1890, 5 per cent.; 1891, 7½ per cent.; 1892, 5 per cent.

The central station is in Earl Street, and the system of distribution is by means of medium-pressure alternate currents reduced by *transformers* in consumers' houses.

Charge for Electric Energy, 9d. per B.T.U. Gas is 3s. 9d. per 1000 cubic feet.

Length of Mains laid, about 30 miles.

Lamps connected, 8000 8 c.-p. Incandescent and 87 Arcs.

The Hove Electric Lighting Company, Ltd.

Offices, 79 Western Road, Hove.
Capital, £40,0000, consisting of
8000 £5 Ordinary; £15,000 subscribed.

Chairman . . Colonel A. J. FILGATE, R.E.

This Company was registered in August 1892, and holds the transferred powers of the Hove Commissioners. A temporary supply station has been erected in Holland Road, Hove, where a low-pressure system with storage batteries is employed.

Charge for Electric Energy, 8d. per B.T.U., with rebates up to 25 per cent., according to consumption. Gas is 2s. 9d. per 1000 cubic feet.

Length of Mains, 6½ miles.

Lamps connected, 6000 8 c.-p.

Hull Electric Lighting.

The Corporation have recently erected a central station for the supply of Electric Energy, under the superintendence of Mr. F. Harman Lewis, the Borough Electrical Engineer, at a cost of £24,000.

The low-tension three-wire system with accumulators is employed.

Charge for Electric Energy, 7d. per B.T.U.

Length of Mains, Lamps connected } no information obtainable.

The Keswick Electric Light Company.

Secretary's Office, 4 High Street, Keswick.
Capital, £5000, consisting of
5000 £1 Ordinary; £3420 subscribed.
Dividends paid—1891, 3 per cent.; 1892, 2 per cent.

The medium-pressure alternate current system with transformers is employed. Water-power being used with "Victor" Turbines.

Charge for Electric Energy is made by special contract with consumers upon a sliding scale of 1s. per candle-power per annum. Gas is 3s. 3d. per 1000 cubic feet.

Length of Mains, about 3½ miles.

Lamps connected, 1 500 c.-p. Arc and 1039 Incandescent.

Leeds Electric Lighting.
The Yorkshire House-to-House Electricity Company, Ltd.

Secretary's Office, WHITEHALL ROAD, LEEDS.
Capital, £100,000, consisting of
19,900 £5 Ordinary; £47,975 subscribed.
100 £5 Founders'; all subscribed.
Quotations since January 1st 1893 (4½ paid) 4¼–4¾.

This Company holds a Provisional Order for the Borough of Leeds, and the supply commenced in May 1893. The system employed is the alternate current medium pressure, reduced by transformers on consumers' premises.

Charge for Electric Energy is upon a sliding scale, with a minimum of 6d. per B.T.U. less 5 per cent for cash. Gas is 2s. 2d. per 1000 cubic feet.

Length of Mains, about 7½ miles.

Lamps connected, equivalent to 10,000 8 c.-p.

Liverpool Electric Supply Company, Ltd.

Secretary's Office, 15 HIGHFIELD STREET, LIVERPOOL.
Capital, £300,000, consisting of
60,000 £5 Ordinary; 45,000 shares subscribed.

Quotations since January 1st, 1893—	Highest.	Lowest.
Ordinary £5 shares 3½ paid . . .	4¼–4½	$3\frac{7}{16}$–$3\frac{9}{16}$
Ordinary £5 shares £5 paid . . .	6¼–6½	$5\frac{1}{16}$–$5\frac{3}{16}$

Dividends paid—1883, 5 per cent.; 1884, 5 per cent.; 1885, 6 per cent.; 1886, 6 per cent.; 1887, 7 per cent.; 1888, 3 per cent.; 1889, 3 per cent.; 1890, 3½ per cent.; 1891, 4½ per cent.; 1892, 5 per cent.

Chairman . . MR. ARTHUR H. HOLME.

The stations are situated in Highfield Street, Harrington Street, Oldham Place, and Lark Lane. The low-pressure three-wire system

with accumulators is employed. Recently a Provisional Order has been granted to this Company for an additional area, including London Road, Prince's Road, Prince's Park, Sefton Park, &c., thus making the present area of supply some 3½ miles by 1 mile.

Charge for Electric Energy, 7½d. per B.T.U. Gas is 3s. per 1000 cubic feet.

Length of Mains laid, 80 miles.

Lamps connected, 70 Arcs and 23,000 16 c.-p. Incandescent.

Morecambe Electric Light and Power Company, Ltd.

Secretary's Office, 18, The Crescent, Morecambe.

Capital, £15,000, consisting of

14,950 £1 Ordinary ; £5356 subscribed.

50 £1 Founders' ; all subscribed.

Dividend paid (June to November) 1892, 5 per cent.

The generating station is in Edward Street, and consists of Stockport and Crossley gas-engines with Dowson gas-making apparatus. The low-pressure two-wire system with accumulators is employed.

Charge for Electric Energy, 7d. per B.T.U. Gas is 3s. 11d. per 1000 cubic feet.

Length of Mains, about 7 miles.

Lamps connected, 50 Arcs and 3000 Incandescent.

Manchester Electric Lighting.

The Manchester Corporation (although owning the gas-works) is now undertaking the supply of Electric Energy. The supply station is situated on the banks of the canal, and the estimated cost of the works at present in hand is about £78,000.

The Corporation is acting under the advice of Dr. John Hopkinson, F.R.S., and the five-wire system is employed. This method of supply is similar to the three-wire system, but still further extends the area that can be economically served by a low-tension system, and is in use at Vienna and elsewhere on the Continent, but hitherto has not been employed in this country. It has the advantage of allowing the current to be distributed at a pressure of 400 volts, and to be used by the consumer at 100 volts without any transforming devices.

The charge for Electric Energy is one specially devised by Dr

Hopkinson and sanctioned by the Board of Trade. A fixed charge of £12 per annum is made for every B.T.U. that the consumer would burn if all his lamps were alight for an hour, and in addition 2d. for every B.T.U. actually used, as indicated by the meter. The object in view is to give specially favourable terms to those consumers who burn their lamps for many hours out of the twenty-four, since their supply actually costs less in proportion to generate than does that of those who only burn the light for an hour or so a day. An alternative charge of 8d. per B.T.U. is made if the consumer objects to such tariff.

The supply began in September 1893, and the capacity of the station is about 18,500 16 candle-power lamps, the ultimate capacity 41,000.

Newcastle and District Electric Lighting Company.

Secretary's Office, 38 Grainger Street West.
Capital, £50,000, consisting of
5000 £10 Ordinary shares; £35,000 subscribed.
£5000 4½ per cent. Debentures; all subscribed.
Dividends paid—1890, 2 per cent.; 1891, 5 per cent.; 1892, 5½ per cent.

This Company supplies part of the central and all the Western portions of Newcastle-upon-Tyne. The medium-pressure system is employed, with transformers.

Charge for Electric Energy, 6d. per B.T.U., with discounts varying from 5 to 20 per cent.

Lamps connected, 50 Arcs and 17,000 8 c.-p. Incandescent.

The Newcastle-upon-Tyne Electric Supply Company, Ltd.

Secretary's Office, Pandon Dene.
Capital, £50,000, consisting of
10,000 £5 Ordinary; £28,000 subscribed.
£15,000 £6 per cent. Debentures; all subscribed.
Dividends paid—1891, 4 per cent.; 1892, 4 per cent.; Interim, June 1893, 2 per cent.

This Company supplies current to the whole of the Northern and Eastern portions of Newcastle-upon-Tyne, under a Board of Trade

License. The generating station is at Pandon Dene; the system employed is the medium-pressure alternate current, with transformers.

Charge for Electric Energy, 4½ per B.T.U. Gas is 1s. 10d. per 1000 cubic feet.

Length of Mains (concentric cables), 10 miles.

Lamps connected, 20,000 8 c.-p. Incandescent and 12 Arcs.

The Northampton Electric Light and Power Company, Ltd.

Secretary's Office, 2 St. Giles' Square.

Capital, £50,000, consisting of

10,000 £1 Ordinary; all subscribed.

£5,000 £5 per cent. Debentures; all subscribed.

This Company has *sole* powers in Northampton under Provisional Order, 1890, and lighting commenced March 1891. The station is in Angel Lane, and the low-tension system is employed.

Charge for Electric Energy, 9d. per B.T.U., subject to 10 per cent. discount. Gas is 2s. 4d. per 1000 cubic feet.

Length of Mains laid, about 4 miles.

Lamps connected, 4500 Incandescent and 12 Arcs.

Nottingham Electric Lighting.

Under License. Messrs. Muirhead & Co. commenced supplying current for Electric lighting in March 1891. The system employed is low-tension by means of overhead wires.

Charge for Electric Energy, 5d. per B.T.U. Gas is 2s. 6d. per 1000 cubic feet.

Length of Mains, about 2 miles.

Lamps connected, 600 Incandescent and 4 2000 c.-p. Arcs.

The Oxford Electric Lighting Company.

Offices, 45 Broad Street, Oxford.

Chairman . . . Sir HENRY MANCE, C.I.E.

The system employed at Oxford is of great interest, being different in many of its features to anything hitherto carried out. A medium-pressure *continuous* current of 1000 volts is transformed

in sub-stations by means of motor-generators (see page 93). Although such machines are used for a similar purpose by the Chelsea Electricity Supply Company, the Oxford Company may claim to be the first to distribute Electricity throughout the whole area of supply by means of medium-pressure continuous current, and the system is well worthy of the careful consideration of Provincial Corporations who propose laying down their own plant for Electric supply.

The Oxford central station has now been running since June 1892, with great success, and the system of control is such that very little attention is requisite at the sub-stations.

The light is installed in nine of the Colleges, the University's Club, and many institutions and shops in the town, while the public street lighting is carried out under a contract with the Oxford City Council.

Charge for Electric Energy, 8d. per B.T.U. Gas is 3s. 4d. per 1000 cubic feet.

Length of Mains, about 12 miles.

Lamps connected, 7000 8 c.-p. Incandescent and 20 Arcs.

Preston.

The National Electric Supply Company, Ltd.

Secretary's Office, 119A FISHERGATE, PRESTON.
CAPITAL, £100,000, consisting of
19,900 £5 Ordinary; £53,025 subscribed.
100 £5 Founders'; all subscribed.

This Company has sole powers for the County Borough of Preston. The station is in Bushell Street, and the low-pressure three-wire system is employed. Preston was the first provincial town to adopt gas as an illuminant, and it is gratifying to see the community is also in the vanguard with regard to Electricity.

Charge for Electric Energy, 7d. per B.T.U., less 15 per cent. Gas is 3s. 7¾d. per 1000 feet, less 15 per cent.

Length of Mains laid, 7½ miles.

Lamps connected, 10,000 8 c.-p. Incandescent and 52 Arcs.

Reading Electric Lighting.

The Electric lighting of Reading was commenced in March 1889 *by a syndicate* under an agreement with the Corporation. The

station is on The Island, Duke Street. Current is supplied on the Thomson-Houston system by overhead mains.

Charge for Electric Energy, 8d. per B.T.U. Gas is 3s. per 1000 cubic feet.

Mains are about 4½ miles long.

Lamps connected, 1400 8 c.-p. Incandescent and 74 1200 c.-p. Arcs.

The Southampton Electric Light and Power Company, Ltd.

Central Station, BACK-OF-THE-WALLS.

Secretary's Office, 23 HIGH STREET.

CAPITAL, £30,000, consisting of

2000 £5 Ordinary ; £3540 subscribed.

4000 £5 Preference ; £250 subscribed.

Chairman . . . . MR. G. T. HARPER, J.P.

This Company has sole powers in Southampton under a Board of Trade License, and is supplying power for the cranes on the quays and elsewhere as well as light. The two 3-ton Electric cranes of the Southampton Harbour Board are worked by this means. The three-wire system, with Crompton-Howell storage batteries, is employed.

Charge for Electric Energy is made on a sliding scale with a maximum of 8d. per B.T.U. for lighting and 6d. per B.T.U. for power. Gas is 2s. 10d. per 1000 cubic feet.

Length of Mains laid, about 2 miles.

Lamps connected, 3000 8 c.-p.

Taunton Electric Lighting.

Borough Electrical Engineer . . MR. H. E. HUNT.

The Taunton Electric Light Company has now transferred its property to the Taunton Town Council. Lighting has been successfully carried out since 1886.

Charge for Electric Energy, 6d. per B.T.U. Gas is 3s. 9d. per 1000 cubic feet.

Length of Mains, about 8 miles.

Lamps connected equivalent to 2150 8 c.-p.

The Weybridge Electric Light Company, Ltd.

Offices, Thames Street, Weybridge.

Under a Provisional Order of June 1891, current is being supplied for both public and private lighting by a high-pressure system.

Charge for Electric Energy, 9d. per B.T.U. Gas is 4s. 6d. per 1000 cubic feet.

Length of Mains, about 7 miles.

Lamps connected, 120 16 c.-p. Incandescent for public, and 500 16 c.-p. for private lighting.

CHAPTER XI.

TRANSMISSION OF POWER BY ELECTRICITY.

THE title of a subject often deters people from even attempting to inquire into it, for though the matter may be familiar enough to them, they do not recognise it under a scientific heading.

For instance, the title of "Electric Transmission of Power" conveys but little idea to many; but yet everybody knows that by, so to speak, putting Electrical Energy in at one end of a telegraph cable, mechanical movement can be obtained at the other end on a dial even thousands of miles away. So, again, when gas is produced and conveyed some miles through gas pipes to be utilised in a gas-engine, it is simply an instance of energy being transmitted. Scientifically explained, in the first of these two cases chemical energy in the battery is transformed into Electrical Energy and conveyed along the cable, at the other end of which mechanical power is produced, and expended in deflecting the indicator needle. In the second instance, the potential energy stored up in coal is conveyed in the form of gas through pipes to an engine, where, by means of the heating and explosive effects of the gas, mechanical power is obtained.

Transformation of Energy.

Such instances as the above serve well to illustrate what is meant not only by Transmission of Power, but also by

Transformation of *Energy*. For we can change the form of energy, although we cannot create it. When it exists in nature, in more or less inconvenient forms, we are thus enabled to transform it so as to make it serviceable in everyday life.

For instance, it is the gravity of the earth—a form of energy—which causes a waterfall; but this is of no service to us until we employ a water-wheel to transform the energy of the falling water into mechanical power. The steam-engine is another instance. In this case coal, although of no use to us when lying in the ground, contains potential energy; and the boiler and steam-engine enable us to obtain from it mechanical power. Similarly, it is possible to transform most other forms of energy from one kind to another.

Transmission of Power.

But the *Transmission* of *Power* is quite a different problem. It has been remarked, that ever since man began to use tools worked otherwise than by hand he had to employ some system of Transmission of Power. It is interesting, and in fact essential, before dealing with the actual subject of this chapter, to see what are the other most prominent methods of transmitting Power for doing work.

Mechanical.

The system most generally used is the purely mechanical agency of wire-ropes, shafting, and belting. For short distances this is often the most convenient, as the mechanical power of revolving shafts can thus be distributed by means of belts right and left to all classes of machinery. There is always a slight loss caused by friction and "slipping" of the belt; but with *long distances* this is very much increased, and, moreover,

power cannot be transmitted satisfactorily beyond a certain distance.

Hydraulic.

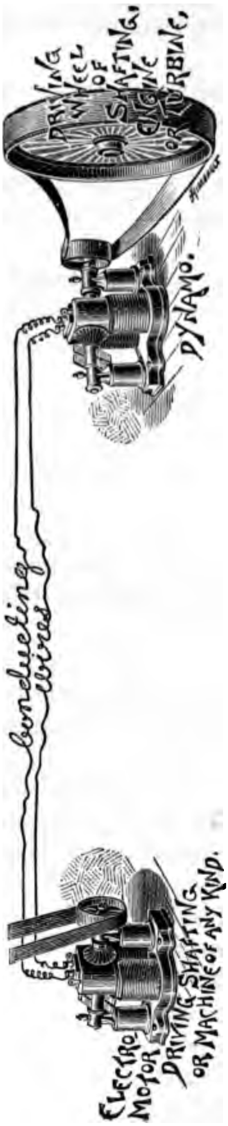
Hydraulic Transmission of Power is another well-known method, and can be distributed by means of water forced through pipes at high pressure to work lifts, presses, &c. This is done in London by the Hydraulic Power Company, whose pipes are laid in most of our principal streets.

If in a well-watered district a good pressure of water can be obtained from some mountain torrent without mechanical means, then of course hydraulic transmission is more efficient and cheap than any other method. This is seldom the case, and, moreover, for mining purposes a great drawback with hydraulic power is that the waste water has to be lifted out of the mine, and that leakage of water through faulty joints or damage to piping makes the roadways slushy and unfit to travel on.

Pneumatic.

Pneumatic power, obtained by compressed air forced through pipes, is also used to some extent, and is especially serviceable for lighter work. This method is employed between the General Post-Office and its district branches, and telegrams enclosed in circular boxes are thus forced through pneumatic tubes for telegraphic transmission elsewhere.

In coal mines compressed air is largely employed, and is especially serviceable in connection with pneumatic drills. It has, of course, the great advantage of being absolutely safe in gaseous atmospheres, because if an accident happens by which a pipe is burst, the ventilation is assisted. The outlay, however, required for compressed air plants is relatively very considerable, while the efficiency is small, and the higher the pressure that is used, the lower the efficiency of the system becomes. Though, therefore, all these systems of transmitting power are



serviceable, none can be termed satisfactory for long distances. The use of pipes with their numerous joints—liable to leakage and loss—is at all times a nuisance. Again, pipes are cumbersome, difficult to lay, and the cost is often prohibitive.

Electrical.

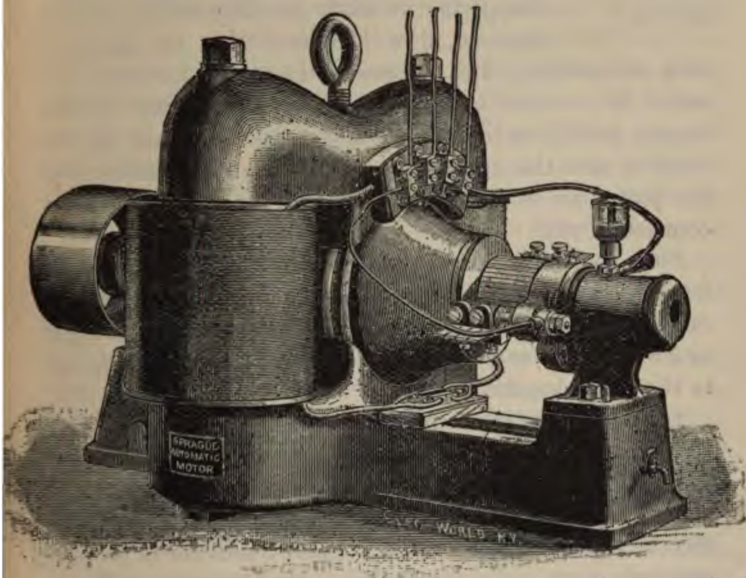
On the other hand, if power can be transmitted by means of a wire or cable which may be bent or laid in any position, the advantages of Electrical transmission are at once seen.

It has already been shown how, by means of the dynamo, mechanical power is converted into Electricity, which may be transmitted along a wire for any required distance. If, therefore, some arrangement can be devised at the other end of the wire to convert the Electricity back again to the original mechanical power, then the problem of Electrical transmission of power is solved.

The Electric-motor.

This result is achieved by the Electric-motor. The discovery of the principle involved in this machine was made accidentally by a workman, who wrongly connected up the wires from a dynamo

in motion to another not in use. To his surprise the latter immediately commenced to work. This discovery, that a current generated by one dynamo acting upon another causes it to revolve, is by some considered the most important in Electrical science since the time of Faraday. It means, graphically speaking, that not only



THE SPRAGUE CONTINUOUS CURRENT ELECTRIC-MOTOR.

can mechanical power be put into a dynamo and Electricity got out, but that Electricity can also be put in and mechanical power got out. In the first instance, the dynamo plays the part of a generator for generating current; in a second, that of an Electric-motor for producing power. Although theoretically the same dynamo

can be worked for both purposes, its practical efficiency is not the same in each direction. The proportions of the parts, the widening of the magnets and armature, are therefore different in each case.

Continuous Current-motors.

The accompanying illustration shows an ordinary type of a very efficient machine, the Sprague continuous current Electric-motor. By comparing it with the illustration of the dynamo, it will be seen that the parts of both are similar. In the case of the motor, however, the action is reversed throughout, as in connecting up the supply mains, and sending Electricity by means of the brushes into the commutator, the armature rotates and the pulley on it works the shafting or machinery it is connected with.

Such continuous current-motors can be readily worked from the same public supply of Electric Energy that is utilised for Electric lighting, and their several advantages as a convenient and economical motive-power are discussed in the next chapter.

Alternate Current-motors.

For the transmission of large currents over any serious distance, whether for power or other purposes, it is necessary to use high-pressure currents, by which it has been shown (page 89) the size and cost of the copper conductor is proportionately decreased. Continuous-current dynamos do not satisfactorily generate currents above some 2000 volts, whereas it is often desirable to use pressure of 5000 volts, and in some recent transmission of power work 15,000 and even 30,000 volts pressure have been safely and economically employed.

When a high voltage is desirable, alternate currents give the best results, and the pressure is readily reduced *by transformers* to any voltage for local distribution.

Unfortunately many difficulties arise in the construction of self-starting alternate current-motors, and although, in the course of time, improvements may be forthcoming, so far no alternate current-motor has been constructed for commercial everyday use.

Multiphase Current-motors.

Multiphase alternate currents may be said to present all the advantages that attach to the use of simple alternate currents, and the facility with which such high-pressure currents can be generated, transmitted, and afterwards distributed, has caused much attention to be paid to them during the past year. As described on page 21, the action of a multiphase current on a magnetic needle is to rotate it, and this rotary action of the current is made use of for motor purposes. It is found that multiphase current-motors will start with a load on and have no "dead points," such as have been detrimental to the use of simple alternate current-motors.

As in Electric transmission of power only ordinary copper cables are employed, the distance between the dynamo and the motor can be almost indefinitely extended, and this alone gives the Electric system a great advantage cver all previously discussed methods. Iron pipes, shafting, or belting are dispensed with, and power is transmitted by the simple means of a cable or wire. This is small, and may be easily handled—even when conveying large quantities of power; it may be bent, or laid in any position, and the loss in transmission may be regarded as no greater for a mile than it is with other systems for a hundred yards.

While the advantages of thus obtaining power by Electricity are at once evident, it is, of course, more economical to use belting or other mechanical means fo short distances. For the same reason one would not this

of fixing telephones for use from room to room, a purpose for which the speaking-tube is simpler and better; while it would be absurd to attempt to use the latter for the long distances over which telephones give such admirable results.

As to how far it pays to transmit water-power by Electricity, must depend not only upon the cost of the water-power and the price of the fuel that would otherwise have to be used, but also upon the efficiency of the power, and number of hours per day during which it can be used. The pecuniary success of such a scheme is quite as much affected by these items as the distance through which the power has to be transmitted.

There are undoubtedly many cases where the utilisation of waste water-power will return a very handsome dividend on capital expended. The natural power of a waterfall is obtained practically free of cost, and although transmission of power always involves a certain amount of loss, there are many instances, in America and Switzerland, of such power being economically transmitted by Electricity a distance of twenty miles or more. In such countries where coal is dear and wood scarce, but where there is abundance of water-power, great opportunities are open for the transmission of power by Electricity. In this country there are, however, few waterfalls of importance that are not already utilised for mill or factory purposes; but in America there are millions of horse-power running to waste.

A general idea of the subject has thus been given, and it is now proposed to instance a few of its applications for practical purposes.

CHAPTER XII.

ELECTRICITY AS A MOTIVE-POWER.

THERE is every reason to believe that the distribution of Electricity for the supply of power will be more important in the near future than even for lighting purposes.

Public Supply.

With Electricity laid on to our houses like water, we may, under proper restrictions, use it for any purpose we please. For working lifts, &c., Electric-motors fed by a public supply current will often prove even more convenient in many ways than the water-engines supplied with hydraulic power from street mains, as at present used all over London. Again, although power can be economically obtained from gas by means of a gas-engine, an Electric-motor takes a tenth of the space, requires practically no attention, and for intermittent work is certainly more suitable.

In many American cities, where the Electric light was rapidly taken up some years ago, the companies have since done much towards making the supply of Electric Power a feature. The manager of a station, where Electric lighting is only just paying its way in the face of fierce competition with gas, finding the demand for Electric Power so prompt and growing, naturally does all he can to extend it. Thus, in some instances, a larger profit has been obtained from the sale of Electricity for power than for lighting purposes.

It has often been remarked that the sale of the residual products—coke, tar, &c.—produced in the manufacture of gas forms an important item in the revenue of a gas-lighting company. In the same way, in supplying Electric light, the company's machinery can be worked profitably during the day for supplying power, for it is in the daytime that motors are chiefly used. Thus a revenue

ELECTRIC MANGLE.

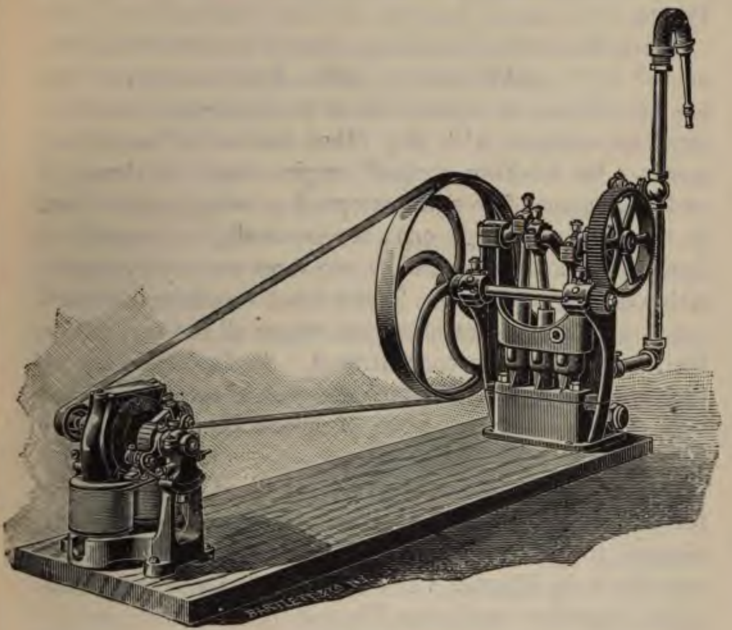
ELECTRIC BUTTER CHURN.

is obtained by a market being found for Electricity when least light is being used.

These remarks are not concerned with what might be done, but with what is being done every day in many American cities, where the grocer grinds his coffee, the tailor works his sewing-machine, and the hair-dresser his *brushes by Electric*-motors from a public supply, and

where restaurants are ventilated and even newspapers printed by the same means.

With an Electric-motor worked by Electricity produced a mile or more away, the machinist runs his lathe, or the carpenter his circular saw. Well can an Electric Supply



ELECTRIC-MOTOR AND PUMP.

Company say, as was said by James Watt, "I have what every subject of your majesty wants—Power."

While the Electric Supply Companies are so busy here daily connecting up house after house for Electric lighting, they are unable to direct sufficient attention to the subject of Electric Power. Theoretically, Electric-motors

can be supplied from the same mains as those that supply light, but in practice it will often be found desirable to run separate mains. As soon, however, as orders for lamp connections begin to slacken, the financial advantages to be obtained will cause them to more energetically push the sale and use of the small motors for the supply of Power.

As to the cost of working Electric-motors when connected up to public supply mains, American experience has proved that at any rate for all small purposes, Electricity can compete with any other method of supplying power. In working a small engine there is always a certain amount of loss, the proportion being greater than in the case of a large one; consequently, if a number of small engines are replaced by one large one a very appreciable saving is effected. This is what occurs in distributing power from a central station, where all the machinery, fuel, and labour are concentrated. Again, there are all the considerations of nuisance and cost of attention in the case of small engines, none of which occur when only Electric-motors are employed.

If a large amount of power is required, and especially for a number of hours per day, it will usually be found cheaper to have separate machinery, in the same way as was shown in Chapter VII.; it is sometimes more economical to produce one's own Electric light.

It is for small purposes, or where power is only required intermittently or for a short period daily, that the convenience of Electric-motors will be most apparent. There seems good reason to believe that Supply Companies will charge lower rates in the daytime for Electric Energy supplied, than at night, when their supply stations are in full work for Electric lighting. With a charge of only 4d. per B.T.U. the use of Electric-motors will

prove not only convenient, but in many instances very economical.

Factory Work.

Besides working Electric-motors from a Supply Company, a variety of opportunities occur for their use in large factories and mines. The work that a steam or gas engine can do, the Electric-motor can also do, and therefore it will be readily understood how important a part Electricity as a motive-power is likely to play in the future.

It must always be borne in mind, of course, that you "must first catch your hare," and so Electricity must first be generated to work the Electric-motor. An instance has been known of a gas-fire being purchased for use in a village where there was no gas, and in the same way the Electric-motor alone is of no service. An Electric installation is necessary; and where steam or water power is already used, a dynamo can be readily added with many advantages.

Hitherto where mills or factories consist of several buildings, either separate engines have had to be erected for each building, or the steam-power conveyed by long lines of shafting over extensive areas. The original cost of this is great in comparison with the simple stringing of Electric wires to motors, and the daily loss of power involved by long lines of shafting and belting is also no inconsiderable item. The Electric-motor is of the greatest service in a large factory or mine, as an economical power-distributor, for by using several independent motors, different sections of the machinery can be started or stopped as power is required, without the necessity of working a long system of shafting for a few machines.

Where water-power is used direct, and the mill has to be erected close to it at the water-level, expensive foundations are necessary. But with an Electric power installa-

tion, the factory can be erected in a cheaper manner at any reasonable distance away, on a natural site free from canal or backwater obstructions, and power brought to it by an Electric cable.

Mines and Collieries.

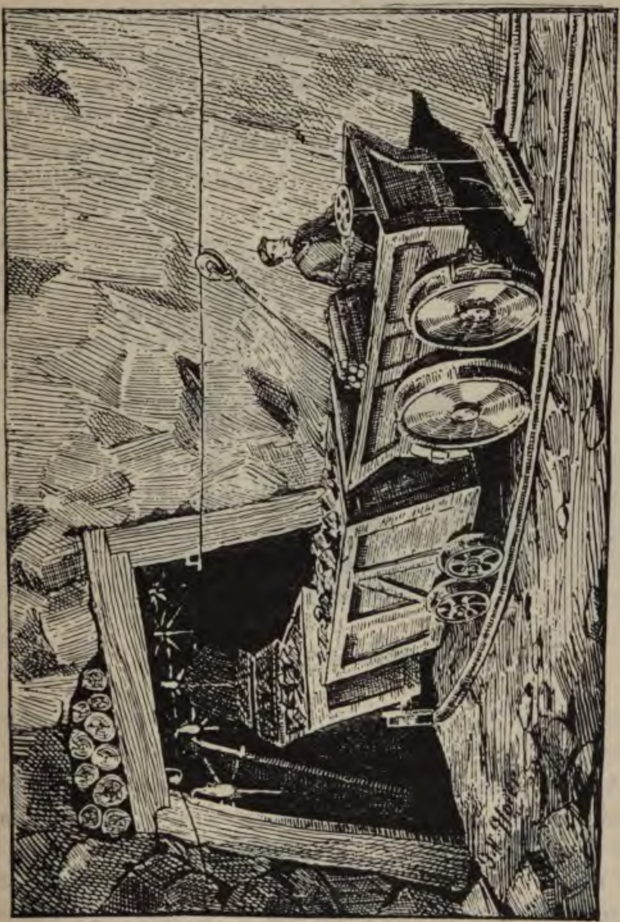
It was shown in the last chapter that by Electric transmission of power natural sources of energy are enabled to be economically utilised, even when situated at a considerable distance from the mines or other industries where such energy can be made serviceable. The advantages the system presents as compared with hydraulic or pneumatic systems for the distribution of power were also pointed out, and for whatever purpose power is required, the adaptability of the Electric-motor will be found unequalled.

In this country, mining engineers and colliery owners have not given Electricity much opportunity of showing what it can do for them, but in the few mines where Electric-motors have been tried they have proved eminently successful.

The compressed air system is mostly in use at present, but, as was pointed out in the last chapter, this system has certain disadvantages. In an Electric power installation, the dynamo takes the place of the air-compressor, the conducting wire that of the air-pipe, and the Electric-motor that of the compressed air-engine. The original cost of an Electric plant is much less, and is not only more efficient but generally more serviceable, while the yearly maintenance is small in comparison to that of the air-compressor and the air-pipes. The cumbersome piping is often difficult to fix, and every angle causes loss through resistance, while Electric cables can be bent to any angle and easily fixed or removed.

Electric travelling and derrick cranes are in very general

use in the United States, and especially the three-motor



MINING TRAMWAYS, LIGHT, AND VENTILATION WORKED BY ELECTRICITY.

cranes (one for each motion) seem likely to prove far superior to many steam cranes. The Electric crane may

be said to afford one of the best instances of the extent to which Electricity can be utilised in the service of man. By its means a factory lad is enabled, on pressing a switch, to raise a piece of machinery weighing many tons, convey it across the works, and deposit it on a railway waggon. Surface trains, hoists, crushing machinery, are in the same way all capable of being worked from the same generating station, while the Electric-motor, on account of its

ELECTRIC-MOTOR AND FAN.

lightness, is invaluable for temporary purposes or where movable power is needed.

Again, perhaps the question which has most troubled mining engineers up to the present time is how to work the ventilator economically without separate machinery at the mouth of the ventilating shaft. In all pits fans must be used to draw off the gases and to circulate air; indeed, in some coal-pits, if the fans were to stop work for half-an-hour it would mean suffocation to those below. The *colliery ventilating* fan therefore becomes of vital impor-

tance. As a rule it is placed too far from the main engine to be worked directly by belts or wire-ropes, and separate machinery is thus often necessary.

Now of the many applications to which the Electric-motor may be put, ventilating work is, if anything, the most suited to it, as the high speed required by the fan is so readily obtained by the motor. Again, the ease with which Electric wires convey power to the awkward and out of the way positions in which ventilators must usually be placed, and the fact that the apparatus can be fixed upside down, or indeed in any position, so long as it is fixed securely, gives to the Electric-motor advantages far greater than are possessed by any other system for ventilation work.

Its uses are thus numberless, and above all it should be remembered that it brings within the scope of mining and industrial operations many wasted sources of natural energy. Although we are apt to be over sanguine when new discoveries are made, yet it may be predicted with certainty, that for every unit of Electricity used ten years hence for light, *ten* units will be used for Electric power.

CHAPTER XIII.

ELECTRIC TRACTION.

ELECTRIC power applied to locomotion must in the near future occupy so important a place in the service which Electricity is to render man, that a separate chapter on the whole subject of Electric Traction is really desirable.

It is now nearly a century since steam locomotion was first invented, and few doubt that in spite of the perfection this has now been brought to, the next century will see a complete revolution—Electricity reigning where steam is now so mighty.

Although but little has been achieved with Electricity for heavier locomotion—railways and ships—much has been done in the lighter work of tramways and launches. In fact, it may now be safely said that the experimental stage has been passed, and the point reached where the perfecting of pioneer inventions becomes not only a commercial success, but also a benefit to the community.

Tramways.

To begin with the tramway question. One of the chief objections, of course, to horse traction is the disastrous wear and tear of the poor animals concerned, caused chiefly by the strain they undergo at each starting of the car, and the continual bodily shaking to which they are subjected in trotting over the hard road.

As is well known, efforts have been made to overcome

this by the use of cable-hauled and steam-driven trams. The cable system, however, is not only expensive, as regards the first cost, but is always subject to the objection that a cable may snap when going up hill, or a brake refuse to act, thereby causing danger to life and property. On the other hand, with steam cars, the special regulations concerning their noise and smoke restrict their efficiency, and result in great waste.

Now, from the foregoing chapter, it will be readily understood how an Electric-motor can be connected to the wheels of a tramcar, causing them to revolve, in the same manner as with a lathe or any other machine. But the difficulty with Electric traction is, how to convey the Electricity produced at the supply station to the Electric-motor on the moving cars.

Accumulator Systems.

The simplest method, and one unequalled from the point of convenience, is to make use of accumulators carrying the stored energy. These need occupy no valuable space, being usually placed under the seats of the car, and connected by wires through a regulating switch to the motor. Such a plan requires no interference with the rails or permanent way, and has been successfully employed, for instance, on the Birmingham Central Tramways, where the working of the tram is so arranged that each car after making a certain number of trips is run into the depot, and readily fitted with a re-charged set of accumulators in a few minutes.

It has been found possible to profitably undertake the maintenance of the accumulators at 2d. per car-mile run, and where, for instance, 100 cars are at work, offers have been made to reduce this rate to 1¼d. This is, of course irrespective of the actual energy required to drive tl car, and may be safely considered as the right allowan

for wear and tear when accumulators are used for traction purposes under proper supervision. With such definite limits for maintenance and expenditure, there is scarcely need to make comparisons between the cost of Electricity and other systems. With horse traction, which is the most in vogue in England, the excess in the variations in the price of fodder alone are said to be sufficient to cover the whole expenditure on accumulator renewals.

A certain loss, however, is always involved in the use of current taken from accumulators, and sufficient current must be allowed not only for drawing the car, but also the additional weight of the accumulators, which is no small consideration.

Conductor Systems.

With a view to overcoming this, systems of traction have been devised by which the Electricity can be conveyed from a supply station to the motor of the car while the latter is in motion, by means of some form of Electric conductor running along the track. All such systems are called "Conductor Systems," while the former methods are conveniently distinguished as "Accumulator Systems." The conductors can be fixed on the surface, underground, or overhead.

Surface Conductors.

Surface Electric conductors in the form of the ordinary iron rails have been used in some instances for Electric traction, but it will be easily understood that this involves considerable loss of Electrical Energy, not only from its leakage to the earth, but also on account of the resistance of the iron rails, and for this reason the system is only practicable for short distances. The railway along the Brighton beach, a quarter of a mile long, is run in this manner, the rails being fastened to wooden logs resting upon the *shingle of the* beach, and with no special insulation for

the conductors. This little railway is highly popular in Brighton, but what with storms from the sea, and prejudice from the local authority, it has had a great deal to contend with.

To work efficiently, the conductor conveying the Electrical Energy must be well insulated, so that there may be as little loss of current as possible. It can be readily understood how difficult it is to have a conductor at once making good Electric connections with a tramcar in motion, and at the same time thoroughly insulated to prevent loss of Electricity.

Underground Conductors.

Conductors, enclosed in a channel with a central slot to allow the free passage of the contact arrangement, have been devised, but in an ordinary street an open channel becomes full of water and clogged with dirt, and the daily working of the line is sometimes a source of anxiety and trouble. It has, however, been successfully used in some instances, as at Blackpool, where the line has been open some time. This tramway is two miles long, and each car has a separate motor and the necessary arrangements for making contact with the underground conductor.

Again, a third rail conductor placed between or at the side of the ordinary rails can be used, but in towns like London, or where there are busy thoroughfares, tramway directors find their two rails cause quite sufficient trouble and do not want another one. Besides, the expense involved in any system of putting down a separate conductor on or under the track of a tramway is very great.

Overhead Conductors.

The last system to which it is proposed to refer, namely, overhead conductors, has perhaps proved the most successful and been the most widely adopted of any system of Electric traction. Not only is the cost of erecting this system

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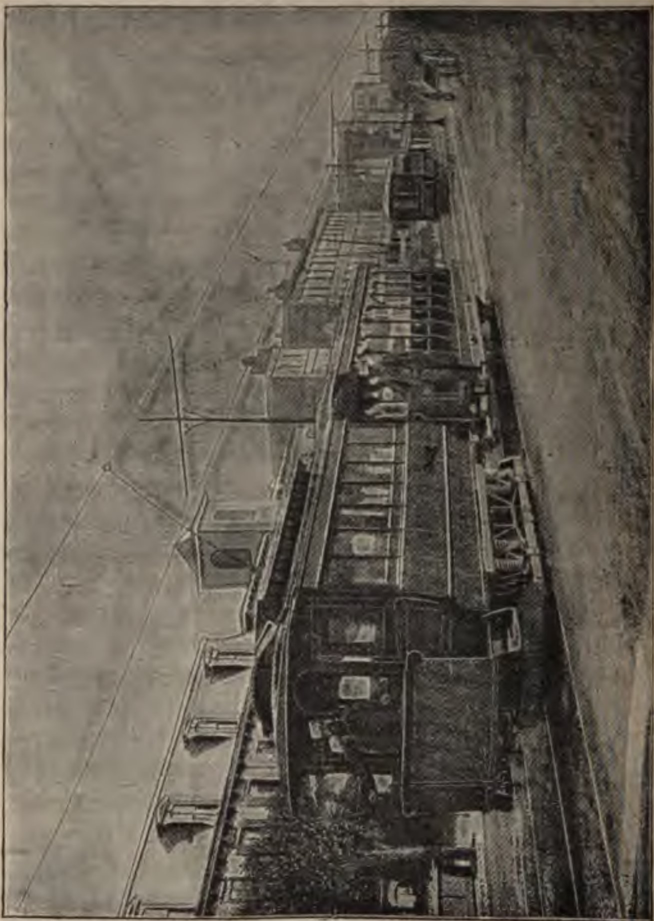
small, but the maintenance of a tramway working in this



THE SPRAGUE ELECTRIC RAILWAY.

way is much cheaper than horse or any other mode of traction. In America, where it is chiefly known as the

Sprague Electric Traction System from the name of the inventor, it is very widely used and with the best financial results. On the South Staffordshire Tramway line, and at Leeds, somewhat similar systems have recently been started, and it is to be hoped that but a short time will elapse before such systems of traction are in use on many suburban or other suitable lines in this country. The illustration shows a Sprague tramcar drawing an ordinary car at Atlantic City, New Jersey. Connection is made with the overhead wire by means of a rolling contact fixed to the flexible rod shown on the top of the car. The current passes through the motor and completes its circuit, returning through the wheels of the car to earth. Neat wood or iron posts are employed to support the overhead wires. These posts are either placed in pairs, one on each side of the street, and connected by span wires which carry the contact cable, or else they support the latter by means of brackets as shown. The cars may be run from any speed to 15 or 20 miles an hour, and can be instantly stopped, without using a brake, by merely reversing the Electric-motor.

In the United States, where the overhead conductor system is very widely employed, many advantages to the travelling public are said to have accompanied the introduction of Electric traction, such as improved road-bed, with consequent smoothness of running, larger and roomy cars lighted by Electricity, and a speed hitherto unobtainable.

In England, overhead conductors would not be permitted along the streets of our larger cities, but it is to be hoped that the æsthetic objections to their use in provincial towns will not seriously interfere with one of the cheapest and simplest forms of traction it is possible to devise.

Electric Railways.

Although underground or surface conductors are objectionable for street tramways, they are advantageously employed on railways. The South London Electric Railway Company have been running their trains daily for more than two years on this system, with satisfactory results. Electrical Energy in this case is conveyed by means of a bare conductor fixed on glass insulators between the two rails. As the car passes over it, a sliding contact-piece collects the current. Here the conductor is not a source of inconvenience, as the whole length of the line forms a subterranean tunnel, where no traffic interferes with the system, and where the conductor is capable of being well insulated. There is no fear of collision, as two distinct tunnels are employed, one for each direction. The whole of the Electric power is generated at Stockwell, and transmitted thence by the conductor to supply current to each train on the line, the length of which is five miles from end to end. The trains, which are built on the American through-passage principle, run at a speed of twenty-five miles an hour.

The Electric railway at Portrush, co. Antrim, is also run on the separate conductor system, though in this case the conductor is carried on short posts, at a height of two or three feet from the ground. It was one of the first Electric lines started in the United Kingdom. Power is obtained from a waterfall, and the working of the line has been so successful that a second railway employing a similar system has since been laid down in Ireland, between Newry and Bessbrook.

The most important example of Electric traction, however, is undoubtedly the Liverpool Overhead Railway. Here again the Electrical Energy is conveyed from the *supply station,* which is situated halfway, by means of

a bare conductor fixed on insulators between the rails which are used for the "return" circuit. The cars are on the American through-passage principle, and each one fitted with its own motor, no gear being employed, but the motor armature constructed on the axle. Ten revolutions of the motor per minute sends the car one mile per hour. There are double sets of rails all the way, and the trains can be made up of any number of cars, but it is proposed at first to work twenty trains, consisting of two cars each, running a train each way every three minutes. The total length of the line is six and a half miles, with fourteen stations, and the contract has been made to run this distance, including stoppages, in thirty-one minutes. This is the real beginning of Electric railways.

The Liverpool line is very much wanted, and should be a great success, as at present there are no means of getting from one dock to another except by omnibuses which run very infrequently, and over the same track as the railway lines, with a consequent rumbling and jolting.

In the construction of Electric locomotives for railways, two, three, or more separate motors may be used, each driving a single axle and pair of wheels. High speed locomotives for heavy trains could be built in this way with four or six driving wheels if necessary, each axle and pair of wheels being driven by separate motors, instead of the driving wheels being coupled by rods as with the compound steam locomotives of the L. & N. W. Railway.

Lightning Express Trains.

When it is considered how rapid are our telegraphic means of communication, and how the telephone trunk lines now enable instant converse to be made between London and the northern cities, it will be recognised how inadequat

for the wants of the age are our present means of locomotion. The commercial demands for a more rapid transit will compel the leading railways to deal with this question of Lightning Expresses running between 120 and 150 miles per hour.

In an interesting pamphlet recently published by Mr. Behr, A. Inst. C. E., it is pointed out that the present express trains between large cities are far from being generally remunerative. The wear and tear of the permanent way is very great, while the frequent shunting of goods traffic and the difficulties of arranging local trains, with all the danger of collisions that this implies, may be said to arise solely from the necessity of having clear runs at certain periods of the day for the express service. A lightning express system which could be arranged for alongside of the present traffic would relieve the congestion of many trunk lines, and add to the safety of working them.

It is totally impracticable to run a steam locomotive service at a greater speed than 70 miles per hour, and the present arrangement of rails is also unsuited to higher speeds, but short trains worked by Electric motors may be safely and smoothly run at frequent intervals on the single or rather triple rail plan proposed. This service will permit of trains travelling at a speed of up to 150 miles with no greater risk than with the present methods. A service communicating with Brighton in 25 minutes, Manchester in 1¾ hours, Glasgow in 3½ hours, and (allowing 1½ hours for the sea passage) Paris in 3½ hours, is a necessary sequence of the invention of telephonic communication. The change from the express service of 60 miles per hour, working on lines that serve also for local and goods traffic, to a lightning express on its own specially adapted rails running at 120 miles per hour, is

not so great as the change from the stage-coach of the past in the early days of the railways. It only needs some broad-minded intellect associated with our leading railway systems to recognise that improvement is needed in the train communication between our great industrial cities, to stir the apathy with which the question is necessarily regarded by those more directly connected with the working of our great railway undertakings.

Another application of Electric traction is the method employed for conveying visitors about the World's Fair during the recent exhibition.

The "travelling side walks," as they are called, consist of a platform fitted with seats, which moves round an endless railway tract elliptical in shape, some nine hundred feet long, at the rate of six miles an hour. Between this and the stationary platform is another platform moving at the rate of three miles an hour. On to this one can step without jar or inconvenience, it being an average walking speed, and in the same way, no greater change is felt in stepping from the slow to the faster moving platform on which are the stationary seats.

The slow moving "side walk" and the more quickly moving side walk cars do not stop at all, and yet it will be seen from the foregoing that the passengers can readily get off or on at any time. The passenger, in fact, stops himself instead of the car. Large crowds can thus be readily moved over short distances, while by varying the regulators a speed of fifteen miles can be obtained. As the cost of construction is not great, some such arrangement will doubtless soon be in work here at one or other of our popular resorts.

It has been suggested that some system of Electric

haulage might be applied to canal traffic. Unfortunately

Canals.

canals are against the interests of the Railway Companies, who have done much to impede such traffic by purchase and competition.

Even with Electric power, it would be impossible to economically work canal boats at a great speed, and canal embankments are also unsuited for such. With *sufficient* boats working on a canal, nothing could be more economical than an Electrical system of traction, as the wires would be suspended along overhead, with stations at intervals for producing current. Loose Electric-motors with screw propeller attachments could be constructed to fit on independently, so that they might be taken from barges when being loaded or unloaded, and utilised only on those ready for traffic.

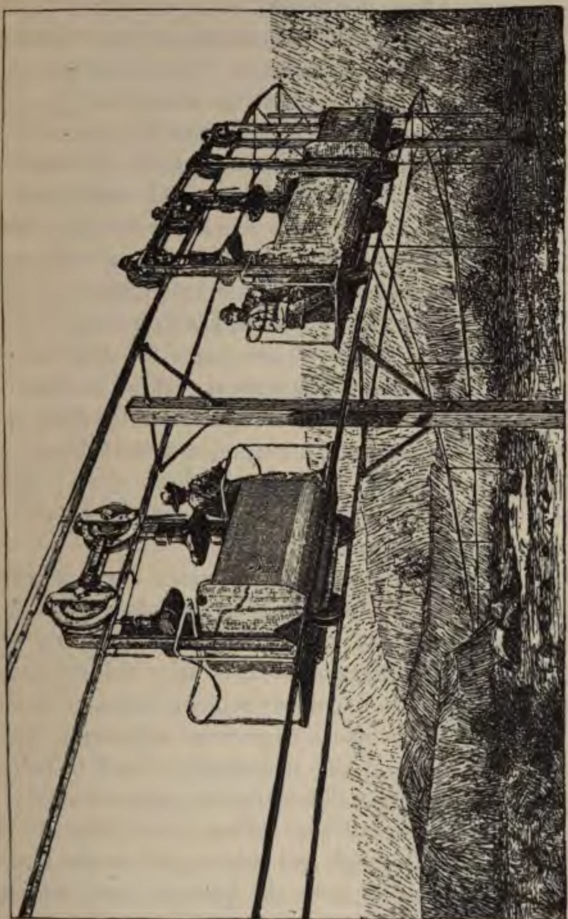
On the Elbe, Rhône, and other quick-running rivers of Germany, France, &c., the haulage of canal boats by chains sunk the whole length of the route is very general. Steam-driven drums on board wind this up in sufficient turns to get the necessary grip, and the swifter the stream the greater is the superiority of such an arrangement over steam tugs. A magnetic pulley has been recently invented, by which the groove of the hauling drum is magnetised, and the sunken chain passing in the groove becomes more firmly and readily held in position by the magnetic attraction. The whole details of this system seem to have been carefully worked out, and it is to be hoped this arrangement will effectually overcome various difficulties, such as the variable strain on the chain previously experienced.

The sketch on page 153 shows a system of overhead

Telpherage.

transport, known as Telpherage. The same steel rods which support the car serve also *to supply current* to its motor. Two or three of the cars

shown may be coupled together to form a miniature train.



OVERHEAD TRANSPORT SYSTEM (TELPHERAGE).

In the future some system such as this may be used with advantage for transporting loads of two or three hundred-

weight each, such as minerals from the mine or quarry, or perhaps for an Express Parcel Post between towns.

Omnibuses. Many people have, doubtless, seen an experimental Electric omnibus careering at times through the streets of London. This is the first step towards the ultimate working of all our street conveyances by Electricity. Further ingenuity must be displayed in devising good starting and stopping gear, and also in constructing accumulators for the special conditions of vibration over our roads. It only wants a little experience, which could soon be gained when half-a-dozen of these conveyances have been at work, to overcome any difficulties that may stand in the way of an efficient Electric omnibus.

Tricycles. Electric tricycles, however, are more for the future, although not far distant. What is required is an accumulator lightened by forty per cent. and yet giving the same output, and with Electrical engineers at work on this subject who have already done so much for accumulator traction, we may rest content that no unnecessary delay will elapse.

Launches. Electric launches are the most successful form of Electric traction, or rather propulsion, that has as yet been devised. This is mainly due to the fact that the driving machinery, of which the screw forms the most important part, is at work in water, which allows of sufficient movement to prevent any strain, Electrical or mechanical, on the machinery. And it is this sudden pull that tends to deteriorate an accumulator. It has been often remarked that Electric launches on the Thames are not fast enough and that a good steam launch is much better, but apart from the question as to whether one should be permitted to go at such a rate along so crowded a river as the Thames, Electric launches are now made to accommodate themselves to any condition of

quick-running streams. There are several now running on the Thames which make, against a *three-mile* stream, from five to five and a half miles per hour, and this with no excessive strain on the accumulators.

Torpedoes.

During the past four or five years very successful experiments have been carried out with a view to making Electricity actuate torpedoes. Undoubtedly this peculiar source of power will shortly supersede all other methods of propulsion for this purpose. Many difficulties, however, still surround this subject, especially when a high speed is desired. This cannot be obtained at present if the source of Electric Energy is in the torpedo itself, and consequently high speeds are only possible by means of a cable to the ship or shore, and through which Electric Energy can be conveyed to the torpedo.

Submarine Boats.

No successful submarine boats have as yet been constructed; but a great deal of experimental work was done at Tilbury in connection with the *Nautilus*, Electricity being used as its motive-power. It is stated that less power is required to propel a boat under water than on the surface, where it is continually climbing up the waves.

There is a great attraction around the subject, particularly for those who have read Jules Verne's "Twenty Thousand Leagues under the Sea." What was considered utterly impossible years ago is now brought within the bounds of actual possibility, and already the advantages of submarine propulsion in some cases are being seen. The Electrical questions involved, however, are the easiest in this case, as the mechanical difficulties of constructing a suitable boat are very great, the limit of flotation being so small. This subject is only instanced here as another of the many apparently impossible things that Electricity has brought within the range of fact.

CHAPTER XIV.

BOARD OF TRADE CHARGE FOR PUBLIC SUPPLY.

Electric Lighting v. Gas.

OF all the Government departments there is none in which the public are so directly interested as in the Board of Trade, for into its charge are committed the interests of the busiest and wealthiest community of the world. Not only are matters connected with shipping, manufacturing, &c., involving the broadest trade control undertaken by it, but also the innumerable details connected with the working of our railways, gas, water, and kindred undertakings.

These multifarious duties have been added to once more, and in no light measure, by the development of Electricity as a means of light, power, and traction. Regulations have been drawn up by the Board of Trade "for securing the safety of the public and for ensuring a proper and sufficient supply of Electrical Energy" under the Electric Lighting Acts of 1882 and 1888.

The regulations deal very thoroughly with the various points involved in the public supply of Electricity, although they are considered in some respects unnecessarily severe. Perhaps from the public point of view it is as well to err on the right side, and no doubt modifications will be made from time to time to bring them up to the standard of such a progressive science as Electricity. Major Cardew, *under whose* control these matters are more immediately

placed, has had so much experience in the practical application of every branch of science, that both the public and the Supply Companies may be said to be in very good hands.

High-pressure Electric supply may only be used under well-considered restrictions formed to ensure the safety of the public. No current exceeding a pressure of 200 volts is permitted to be brought into a house, and the Supply Companies are prohibited under penalty from supplying current to defective house-wiring.

A unit, known as the Board of Trade Unit (B.T.U.), has been decided upon, by which all charges in future for Electrical Energy are to be made, and as this unit is unintelligible to large numbers of consumers, a few words regarding it may not be out of place.

The Watt.

The unit of energy is arrived at by multiplying the *amount* of current by its *pressure*. For instance, a current of 10 ampères (an ampère is the unit of current) with a pressure of 100 volts (a volt is the unit of pressure), represents 1000 watts (the watt being the unit of energy). In the same way a current of 20 ampères with a pressure of 50 volts represents the same amount of energy, since $20 \times 50 = 1000$.

The B.T.U. 1000 Watt Hours.

In the Board of Trade Unit a time period has to be included, and since one watt (the unit of energy) used for one hour (called one watt hour) is considered too minute for trade calculation, 1000 watt hours has been taken as more convenient, and is called the Board of Trade Unit. For instance, in a house where Electricity is supplied at 100 volts pressure, and a current of 10 ampères is consumed in one hour, 1000 watt hours (the Board of Trade Unit of Electrical Energy) has been consumed. Or again, if half the amount has been supplied but for two hours

$100 \times 5 \times 2 = 1000$ watt hours, the B.T.U. in the same way. From this it will be seen that the ampères of current used, multiplied by the hours in use, and then again by the pressure at which the current is supplied, give the total (in watt hours) of the Electrical Energy consumed. The maximum charge permitted in London per 1000 watt hours (the B.T.U.) is 8d. In the provinces a higher charge is permitted, while abroad, where a similar unit is adopted, the equivalent of 1s. per B.T.U. is charged in Paris, and 1s. 0½d. per B.T.U in Madrid.

The amount of Electrical Energy constituting a B.T.U. is about equal to the Electricity consumed by seventeen 16 candle-power lamps burning one hour (or one 16 candle-power lamp burning seventeen hours). As the average charge of the Supply Companies is 7¼d. per B.T.U., it follows that at this rate a 16 candle-power lamp will cost rather under ½d. per hour, and an 8 candle-power lamp about ¼d. per hour.

These costs are based upon the amount of Electricity consumed by the Ediswan lamp, which is stated in the Edison and Swan Company's List to absorb four watts of Electric Energy per candle, so that an 8 candle-power lamp absorbs about thirty-two watts, and a 16 candle-power lamp about sixty-four watts.

Any cheapening of the cost of Electric lighting must for the present be looked for in the direction of a more economical lamp, that is, a lamp giving the same candle-power of light and consuming *less* Electricity. It is quite conceivable that in three years' time good lamps will be supplied with an increased economy of one-third. Thus, without any reduction in the charges at present made by the Public Supply Companies, the cost of Electric light *would be* reduced one-third or more, according to what-

ever increased economy improvements may bring about in the manufacture of incandescent lamps.

Meters. The meters by which a Public Supply Company make their charge for Electrical Energy must be approved of, both in construction and principle, and certified by the Board of Trade in the same way as gas or water meters. Thus, although occasional meters may cheat (they are after all chips of the old block—the gas meter), every precaution is taken to obtain accurate measurements. The accuracy attained by most Electric meters is remarkable, and when they do cheat it is almost invariably found to be against the Supply Company.

As to the advantage of paying for a supply of Electricity by meter, there can be no doubt. In the early days of Electric lighting, when a fixed price per annum was charged for each lamp, there was no incentive whatever for a consumer to economise his light, and the Supply Company had no means of ascertaining whether their supply was a source of profit or loss in any individual case. The best paying supply stations and the most satisfied consumers are those where the Electricity is charged for by meter, and not at a fixed charge per lamp per annum.

It should be pointed out that with gas it is impossible to measure by a meter either its light-giving power, its purity, or the quantity of sulphur or air mixed with it. The utmost a consumer can do is to see he has good regulating burners, which shall prevent as far as possible the gas being forced through, and a blue flame instead of a yellow light given off.

With Electricity it is quite different, for as Professor Forbes (who has given this subject considerable attention) has said, "When we have measured the *quantity* consumed, there is only one *quality* which can exist, and that

is its pressure." With Electric inspectors appointed to see that the pressure of the public supply is always maintained constant, the consumers' interests are amply looked after, and far more so than where gas is used.

An even pressure of the current supplied by a Company is more important to the consumer than may appear at first sight. A five per cent. reduction of the pressure not only means a five per cent. reduction in the Electrical Energy charged for, but it means a thirty per cent. reduction in the power of the light given by the incandescent lamp, which is constructed to glow at a certain specified pressure of current.

Again, if too great a pressure be sent through the lamps, their life is considerably shortened, although consumers are often pleased with the additional power of light obtained. In the same way, by fixing in a lamp of wrong voltage, that is, one constructed to burn at a greater or less pressure, too little or too much light is obtained. It is, therefore, not only desirable for the Electric pressure of a public supply to remain constant, but also uniformity in the voltage of incandescent lamps is important for Electric lighting to be successful. Fortunately the Edison and Swan Company are fully alive to this, and the care taken in the manufacture of their lamps cannot be denied.

Electric Light v. Gas.

In making comparisons between Electric Light and Gas, many considerations come in that are not often taken into account. The position and arrangements of the Electric light always largely affect the bill which is rendered quarterly for the Electricity consumed. For instance, in office lighting, where a regulating argand burner consuming 5 feet of gas per hour, giving 16 candles of light, was previously used, the writer found that a 16 candle-

power incandescent lamp when suspended vertically under a shade had a blinding effect, and an 8 candle-power lamp had to be substituted. Well-directed light is everything, and this is certainly carried out with much more economy by the Electric Light than by Gas.

In reference to the arrangements of lights in houses, it is not proposed to deal here in any way with what is termed Artistic Electric Lighting. The expression is far too wide in its application, and individual taste is such an important factor in all artistic matters, that what one person considers fit and suitable, another may think entirely out of place.

The ideal light is undoubtedly daylight; its combination of sun and shadow brings out and accentuates the beautiful features of everything in nature in a degree that can never be attained by artificial means. Of all artificial illuminants Electricity undoubtedly approaches nearest to an ideal light; but because it permits of treatment and effects that have never been hitherto possible, the straining after something novel often produces results at once unpleasant and inartistic.

The mistake is often made in Electric Lighting of flooding a room with light, thus destroying the shadows, and doing away with all repose and natural effect. Professor Herkomer has shown that the necessary "make up" of actors is largely due to footlights throwing light *up* on the face and destroying the shadows that daylight *down* from above has accustomed us to. In the same way, unless skill is employed in arranging Electric lamps in a house, the ease with which they can be fixed at any angle readily allows an entirely false light to be thrown on the features, which are thus rendered unbecoming (*sic*).

A certain amount of shading is sometimes found necessary from the too searching power of sunlight, so also

shading is necessary to prevent Electric light from wearying the eyes. The globe enclosing an ordinary gas jet absorbs from 20 to 40 per cent. of the light; but very often a great deal more than this is unnecessarily absorbed in the shading of Electric lights. For instance, after fixing a globe, absorbing perhaps 30 per cent. of light, over an Electric lamp, the carbon filament can be slightly seen; and an obscured lamp, absorbing perhaps another 20 per cent. more light, is fixed up in place of the previous clear one.

It is always a much easier thing to show what should not be done than what should be done—for which experience is ever the golden key. The present object is rather to point out how seldom a true comparison can really be made between gas and Electric lighting.

It was hoped that after Electric lighting had been in general use for a year or two some satisfactory estimates of its cost, as compared with gas, would be forthcoming. This is far from being the case, and it is not uncommon to hear the most extraordinarily divergent statements concerning the cost of Electricity supplied for lighting London houses.

In some instances the cost has been stated as enormous, and inquiry has shown that the consumer finds Electric lighting so readily adaptable to all manner of out-of-the-way places, that he has allowed his decorator to work lamps into the ceiling or the cornices, and has three times the number of lamps he had previously gas jets, and yet the effective power of light obtained is the same. Or perhaps the house has been newly decorated, and where the small gas-burner in a large obscured globe previously gave sufficient light for one long corridor, a 16 candle-*power lamp* is now fixed in the globe, or two or three such

lamps are suspended at different points to give a brighter effect.

This is no exaggeration, as it is invariably found that people adopting Electric light are determined to have their rooms well lighted, and will not put up with the inferior illumination they have often had before with gas or oil lamps.

There is, of course, no reason why a consumer should not have as many lights as he likes—nothing is more charming or comfortable than a house well lighted by Electricity; but then he should not make comparisons with his previous gas bill, and say that although the Electric light is very nice and convenient, it is dreadfully expensive. On the other hand, apparently ridiculous statements are made by others of the small amount of Electricity consumed in their houses, yet in neither instance is it the meter cheating.

The arrangements of the wiring of a house, and the proper fixing of switches to control suitable groups of lights, mean a very great deal in the economy of Electric lighting; but all the trouble is wasted unless these switches are turned off when the light is not required. It seems such an easy matter, and yet it is so seldom done.

In the use of gas, a considerable quantity is wasted in the course of the year, as, for instance, by lighting all the bedroom jets at sundown, and leaving them glimmering until required. With Electric lighting there need be no such waste. In a valuable and interesting paper read before the Society of Arts, December 1890, by Mr. Frank Bailey, the Engineer of the Metropolitan Electric Supply Company, he said: "It may be thought that an estimated use of a lamp for only about 200 or 300 hours per annum is very low, but it should be remembered that the Electric

light need only be used when it is required, as the ease of switching it on or off makes us forget all our past troubles in hunting for gas-taps and matches. With ordinary care, the average cost of burning an 8 candle-power lamp for domestic use need not exceed 10s. per annum."

Since this statement was made experience has shown that the average cost of Electric lighting is considerably below this figure. The following table has been carefully compiled from the statistics kindly furnished by certain of the leading London supply companies, and shows the average cost of Electricity for an 8 candle-power lamp per annum, when used for various purposes:—

Average cost of Electricity for an 8 c.-p. lamp per annum.

Clubs	20s. to 25s.
Public-houses and restaurants	18s. to 24s.
Hotels	18s. to 23s.
Theatres	9s.
Offices, large	7s. 6d. to 10s.
Do., small	4s. to 6s. 6d.
Chambers and flats (do.)	5s. 6d. to 8s.
Churches	3s. to 4s.
Shops *—	
1–50 lamps	9s. 8d.
51–80 lamps	9s. 3d.
81–100 lamps	8s. 6d.
Over 100 lamps	8s.
Houses and flats—	
1–50 lamps	8s.
51–80 lamps	6s. to 7s. 3d.
81–100 lamps	5s. to 6s.
Over 100 lamps	3s. to 5s.

* The best London shops in and around Bond Street seem to form an exception to these figures, as it is found that in this neighbourhood the larger shops (*i.e.*, using over 1000 units per annum) show an average cost per 8 candle-power lamp of 6s. 6d. to 9s., and the small shops (*i.e.*, using *less than 1000* units per annum) 4s. 6d. to 6s. 6d.

It will thus be seen from the return of shops and houses, that where large numbers of lamps are installed, their average consumption is considerably less than for a small number. This may be partly due to the fact that large numbers of private houses in London have lamps wired for that are only used on special occasions, while other large mansions are shut up for many months in the year and no light used at all. While, therefore, these figures may be of service as indicating the cost of Electric lighting, it should be remembered that there is only one London, and few provincial towns and cities have large houses or buildings with hundreds of lamps wired for, many of which are but seldom used.

With reference to an indirect comparison of the relative economy of gas used in different ways for illumination, the following figures may also be of value:—To produce 1000 candles of light for one hour by burning gas in the usual way, at least 312 cubic feet of gas are required. This gas, if used in a gas-engine working a dynamo, would produce sufficient power for the supply of incandescent Electric lamps giving in all, over 2500 candles of light, or of 12 arc lamps giving about 1000 candle-power each.

However interesting comparison with gas may be for purposes of calculation, practical experience affords daily evidence of the fact that the price of gas has no more influence on the price of Electric light than the price of candles has on oil. People have continued the use of gas, while the price of oil has been constantly declining, and only because of the superiority and greater convenience of gas. For the same reason they will continue the use of the Electric light, even if the price of gas may be materially reduced in the future for the purpose of competition.

It has been shown that, while gas raised the temperature near the ceiling in a certain hall 40 degrees in three hours, the Electric light only raised it 1½ degrees in seven hours. Such facts as these must appeal at once to all. Professional singers and actors, in fact all who need to exercise their voices, quickly appreciate such differences in the temperature and composition of the atmosphere. But the influence on the temperament generally is still greater, as the atmosphere, no longer saturated with gaseous compounds, does not depress, and the cheery influence of the Electric light on the mind and on our sensitive nerve systems of the present day cannot be too highly estimated.

The possible uses of gas produced at a low cost will cover a broad field. As an illuminating agent, however, in the same way that gas took the place of oil and candles, it is itself being gradually but surely displaced by the superiority of the Electric light.

No one can longer doubt this when the Chairman of the Gas Light and Coke Company himself installs the Electric light in his house, and if people still exist who nurture the idea that much has to be done before it is generally used or can become commercially successful, they are simply deceiving themselves to no purpose. To such it is as well to repeat Professor Forbes' words, "The production of gas is only a somewhat extensive laboratory experiment enlarged to a commercial scale. The distillation of coal and the subsequent treatment by condensers, scrubbers, and lime-purifiers, previous to its admission through the regulator and station-meter to the gasholder, is really a complicated process compared to the production of electricity."

At the present time no less than 651,000 Electric lamps are being supplied in London by the Electric Supply Companies. At least another 155,000 lamps are

being supplied from private installations, thus making already a total of some 800,000 lamps that the Gas Companies would otherwise be supplying.

Yet in spite of these large and convincing figures it is frequently stated at the meetings of the principal Gas Companies that no diminution is found in the amount of gas consumed for lighting purposes. If this really be the case, there is the one obvious answer, that this is due to the shops, restaurants, &c., where Electric light is not used, having to burn more gas, to favourably compare with their more go-ahead neighbours.

CHAPTER XV.

ELECTRO-THERAPEUTICS—ELECTROCUTION.

THE study of the curative powers of Electricity, when properly controlled and applied, has of late made great and important progress, and it is now recognised that Electricity as an agent to cure or to palliate disease, can be employed in a definite quantity to a definite part with a definite object.

It has been often urged that too little science and too much quackery has hitherto been displayed in this branch of science, and certainly Electro-Therapeutics—the treatment of disease by Electricity—requires most careful study by trained scientific observers, before definite statements of curative effects can be accepted. But the stage of empiricism in electro-medical work has now been passed, and, with the attention being directed to the subject by eminent scientists of all countries it can be but a short time before, in electro-physics, as in other branches of the healing science, a sound and precise system of treatment will be evolved, based on the principles of electrical as well as of medical knowledge.

In our own country, there are a few of high standing in the medical and electrical world who have systematically investigated and studied the principles governing the action of Electricity when applied to medical science. So recent, however, is the development of this branch of the healing art, that their names are as yet comparatively

unknown to the world at large, and the sufferer who has determined to try everything too often drifts into the hands of the purveyors of so-called Electrical cures.

By the glib use of the word Electricity, the charlatan is enabled to surround his proceedings with the profound mystery necessary to deceive people whose common-sense would otherwise enable them to appreciate the absurdity of many of the claims set forth.

Where Electricity is the agent, seeing is not always believing, and visitors to medical quackeries must be especially warned against believing any so-called convincing demonstrations they may be shown. The public, it is said, love to be humbugged, and with the reiterated statements constantly before their eyes of the curative effects of Electricity, it is hardly to be wondered at that the advertising quack is the one who benefits.

Of all the quack appliances of the present day, the electropathic belt has certainly been the most ensnaring. Its charms, its wondrous effects, and its simplicity have been trumpeted throughout the land, while its curative powers as advertised were so omnifarious that, if it did not cure *the* one disease, it *might* cure some other latent trouble a perturbed reader can so readily conjure up.

The sale of these appliances has been largely assisted by the difficulty generally experienced of obtaining any reliable information as to their Electric properties. Zinc and copper are undoubtedly present, therefore why not Electricity? and why not curative results?

It has been shown in the best medical practice that, in supplying constant current Electricity from external sources, any current *below* five or ten milliampères* is useless for the majority of cases, although where the head forms part of the circuit a current of two milliampères

* One milliampère is one-thousandth of an ampère.

(one five-hundredth of an ampère) is sometimes employed. In an electropathic belt, even if properly connected up—which usually is not the case—the Electric Energy produced by the discs of zinc and copper, when acted upon by the perspiration of the body, can be *but a fraction of one milliampère*, say $\frac{1}{100}$th to $\frac{1}{400}$th, according to the moisture or dryness of the skin.

The skin is the greatest factor in all such work. It is well known that the interior of the body (the blood-vessels, muscles, tissues, &c.) has a very low resistance to the passage of Electric current, and that when tests are made on the body the very high resistance shown is due to the skin alone, and this resistance of the body is lower when the skin is damp.

In an experiment made by Mr. H. E. Harrison, B.Sc., the current given off by a certain Electric belt was shown to be as small as one hundred-millionth of an ampère. When the belt was placed around the body of a man with a rather damp skin "at first there was a current of one fifty-thousandth of an ampère, and at the end of five minutes no current could be detected, that is, the current (if any) was distinctly less than one hundred-millionth of an ampère." Even homœopathic doses of Electricity may surely be given in too minute a quantity.

More recently Mr. T. E. Gatehouse, the well-known Electrician, performed certain apparently conclusive experiments showing that, under the most favourable conditions—by deliberately wetting the portion of the body the belt comes in contact with—the current generated by such an appliance does not overcome the skin resistance, and cannot possibly therefore materially influence the body. Mr. W. H. Preece, F.R.S., the Chief Electrician to the Post Office, to whom Mr. Gatehouse showed the belt, sent *him a letter* to the effect that so far as he could see from

examination of the appliance, and from the result of the test, it would be quite impossible for the belt to generate a current of Electricity through the body.

Such, therefore, is the value of electropathic belts from an electro-medical standpoint, and it may safely be asserted that if any of the widely advertised nostrums have really produced beneficial results, they have been due far more to "faith cure" than to any other cause. The *Electrical Review*, notably among Electrical journals, has given much valuable and interesting information concerning electro-therapeutics in its columns, and deserves credit for the stand it has throughout taken against such delusive quackery.

Before leaving this part of the subject, it may be pointed out that there are Electric brushes, Electric corsets, Electric plasters, and many other such appliances for the credulous, and doubtless "faith-cures" have been made. When buying Electric brushes, the purchaser may be informed that the cause of the compass needle moving when brought near to the brush, is due to the brush being charged with Electricity—whereas the optical effect is obtained in the same old way as at school, by secreting a small magnet at the back of the brush. Magnetism has never been shown, so far, to have either beneficial or detrimental effects upon the human system, but an attempt is thus made to confound it with the undoubted curative properties of current Electricity when properly applied.

Although such inevitable drawbacks must be expected at the inception of a new branch of the healing science, it is satisfactory to know that great and valuable progress is constantly being made by earnest workers. In our own country, notably at St. Bartholomew's, London, and at other special hospitals devoted to cases of paralysis, &c., there are already distinct Electrical departments, and the

most enlightened of our scientific men are daily learning to grapple more and more with the complex physical conditions invariably encountered in electro-therapeutics. In America much has been done. In France such masters of medicine as Apostoli, Charcot and others have given overwhelming evidence of the efficiency of Electric currents, while in Germany Dr. Erb, the great German electro-therapeutist, in a valuable work, mentions a wide range of diseases in which from his own experience and cases it must undoubtedly be accepted that Electricity has powerful palliative and curative effects.

As Electric currents have certain properties, follow certain laws, and their application is followed by certain effects, it will be readily understood that for such treatment to be rationally administered thorough knowledge is essential as to the dose and to the method of applying it, having regard to the ever-varying conditions of the human body. The need for accurate dosage is, in fact, almost as important with Electricity as with drugs, and without it there can be no proper understanding of the effects produced; no scientific methods of treatment with a definite object. In the same way as in medicine, drugs need to be measured or weighed and the doses accurately prescribed, so with Electricity, measurement is of the first importance in Electrical treatment.

Again, the human body is so complicated and individualised a structure, differing from all other conductors in not being influenced by currents in quite the same way, that what form of current is most beneficial, and what method is the most suitable for administering it, are salient features in successful treatment. Dr. Erb has rightly stated that the art of the electro-therapeutist consists in selecting or devising the best method for each individual case and carrying it out in the best way.

Without in any way attempting to thoroughly deal with the subject, it may be interesting and instructive to a large class of readers to know some of the procedures and possibilities of Electricity for the cure of disease. Mr. H. Newman Lawrence, in some valuable papers recently contributed to the *Electrical Review*, and Dr. Hedley, in a recent work, deal very thoroughly and systematically with the question as to the beneficial influences of different forms of Electric currents.

Continuous Currents.

Of the three forms of currents there are—First, Continuous Currents, which usually are termed in medicine Galvanic Currents, from the fact of their being generally obtained from galvanic batteries. Such currents are said to have great influence on the absorptive and nutritive processes. Their chemical or electrolytic action in breaking up and decomposing morbid products, combined with their direct action on nervous centres and nerves, gives them, it is said, a possible range of action of bewildering extent and complexity.

A very remarkable property again is what is termed their "cataphoric" action. This is best described as the ability of the Electric current to introduce drugs into the body. It is easily shown that "medical substances in solution applied to the skin at the positive pole traverse the skin into the body and can be detected" in various ways. It is impossible to appreciate how this method of medication may develop in the future, as there seems reason to believe that, in certain cases, as much of the drug is brought to bear on the affected part as if administered through the mouth, and this without the destructive effect that drugs undoubtedly have on the process of digestion.

Interrupted Currents, sometimes termed Coil Currents

(from the fact of their being obtained from induction coils), are divided into two classes, viz., "*Interrupted Direct*" *Currents* (from the *Primary* of the induction coil), and "*Interrupted Induced*" *Currents* (from the *Secondary* of the induction coil). The latter are often termed "Faradic" currents, from Faraday, the inventor of the Induction Coil.

Interrupted Currents.

Interrupted Direct Currents are largely of the nature of continuous currents, but are of greater electromotive force than if proceeding direct from a galvanic battery. It is for this reason they are said to be "more pungent and penetrating." These, as well as the Interrupted Induced Currents, have been long recognised as of great value for medical purposes, and are generally resorted to when a stimulating or exciting action of nerve muscle is sought. Another effect is said to be their "pain-killing" properties, as by overstimulating the affected part, it becomes benumbed, and Faradic currents especially are often usefully employed in neuralgias. Interrupted currents influence the body according to their current strength and their rate of interruption or vibration, and there is still need for much further investigation as to the influence different rates of vibration have upon the sensory nerves.

Alternating Currents.

Alternating Currents, generated from a dynamo, differ considerably from the interrupted induced currents obtained from induction coils, and they appear to possess important features in the treatment of nervous disorders, by reason of their smoothness and regularity. In dealing, however, for medical purposes, with any current, whether continuous or alternating, generated from dynamos, certain measures have to be taken to guard against an unexpected and undesirable increase of Electric Energy. The means by

which such difficulties may be satisfactorily overcome, and the supply, whether continuous or alternating, obtained from the street main for medical and surgical purposes, has been fully dealt with in the *Lancet*.

The methods of application, again, are a subject upon which much investigation has been spent. Individual susceptibility depending partly on peculiarities of constitution and temperament, is said to vary in an astonishing manner, and whether the action shall be "general" or "localised" is of importance. In "Hydro-Electric Methods," recently published by Dr. Hedley, he deals among other matters with the Electric bath, as offering an invaluable means of applying Electricity, whether continuous, interrupted, or alternating. The painless and evenly distributed current of the bath should make it one of the best methods of electrisation; but to take them as if they were salt-water baths on the chance of their doing good is like taking a drug haphazard, and with no regard to its definite action.

Professor D'Odiardi has also recently been carrying out some most valuable work in this new field of Electro-Therapeutics, and his methods are well worthy of the careful attention of any one interested in the scientific application of Electricity. Dr. D'Odiardi utilises Electricity at different pressures, from 4 volts to some 30,000 or more, whilst in some apparatus the Electricity is conveyed through liquids containing chemicals, or through certain gases.

By the variety of its application, the same Electricity can produce sleep or wakefulness, increase or diminish the breathing power, stimulate the digestion or the reverse.

The direction of the current has also been shown by him to materially influence the effects obtained, as an ascending current in the spine produces effects very widel

different from a descending one. Again, while in some treatments the current is not allowed to scatter before it reaches a certain distance into the subjacent organs, by another method it can be made to go through the organism like a light through a Fresnel lens.

A careful consideration of the variety of the methods by which Electricity can be utilised in the treatment of diseases would seem to show that Electrical treatment like Hydro-Therapy must be carried out at special establishments. It is no use for a doctor to apply Electricity for a few minutes and then to go on to the next house. If patients are to be benefited, their "cure" must be undertaken in some establishment similar to the "cure" resorts of the Continent. The establishment of such an Electrical hospital in London, under sound scientific management, would be of great advantage in developing Electrical methods of treatment; and, from the cases that have been already dealt with, there seems no doubt that diseases hitherto deemed incurable can be most successfully grappled with.

No really beneficial result, however, can be expected from Electricity in the treatment of disease, unless it is applied under the direction of a thoroughly qualified scientist with a special training in Electrical methods. This point cannot be too strongly urged, and if once it be understood that with Electricity, as with drugs, an injudicious use or empirical treatment may be attended with serious ill-effects, the necessity for rátional treatment and careful administration will be appreciated.

The applications of Electricity to medical and surgical apparatus again offer a very wide field. As an aid to medical diagnosis, a stethoscope has been invented combined with a microphone by which the various sounds of *the human body* can be intensified to an enormous extent,

and sounds detected that would otherwise be too feeble to be apparent. Again, by means of a minute incandescent lamp apparatus the cavities of the face can be examined, or the pharynx, the stomach, the eye or the ear illuminated, and the diagnosis of suspected disease assisted and rendered more certain.

Leading surgeons have been only too willing to avail themselves of various Electrical appliances by which many delicate and skilful operations can now be performed with an ease and simplicity that five years ago were unknown. Dr. Felix Semon, among other leading surgeons, has a most complete apparatus for every description of electro-surgical work, and among his many ingenious arrangements may be noted one by which massage treatment can be applied to the throat through an electrically rotated disc controlled by the hand.

Although Electricity has thus already accomplished much in the treatment of disease, the scope for further development is very great, and new features are being constantly brought to light. Only recently, for instance, when experimenting on massage, Mr. Tesla was able to demonstrate that the human body, well insulated in the air, can be *heated* by connecting it with rapidly alternating high-pressure currents. It would seem that this "bombardment" of the body with such currents offers another channel for the effective treatment of disease. The heating seems to be merely superficial, that is, in the skin; and it would act "whether the person operated upon were in bed, walking round a room, whether dressed in thick clothes or reduced to nakedness."

Electrocution.

Turning now from the subject of "the current that cures," it may not be uninteresting to note some points in connection with "th current that kills."

So much alarmist nonsense has been talked of the death-dealing results of Electric currents, that the brave and fearless in other respects are as the most timid when handling or touching even such ordinary apparatus as lamp sockets, Electric switches, or other details of house-wiring. There is a vague fear that something will happen, and this same feeling is present whenever Electrical matters are in question. It is true some fatal results have happened, but Electricity does not kill people wholesale, as with dynamite, gunpowder, or coal-gas explosions, nor is the list of fatal accidents to be compared with deaths due to exploding or overturned oil lamps.

It cannot be too clearly understood that the Electrical pressure (averaging 100 volts) used in our houses is such that the most delicate person cannot be affected by any shocks received. Electricity at such low pressures is quite harmless, and in view of the experiments at the Royal Institution, in February 1892, when Mr. Tesla received shocks from Electric currents at a pressure of some 100,000 volts, it may be rightly asked, If Electricity at a *low* pressure is harmless, and at a *high* pressure equally so, what is it that produces the fatal accidents to human life that have occasionally been recorded? The reply is, that something more than pressure is required to bring about fatal results, and that unless a certain *quantity* of current is communicated, at a pressure sufficient to overcome the skin resistance of the body, no fatality ensues.

The ability to bear Electric currents varies in different individuals, and taking the minimum resistance (given by Dr. Waller) of the body at 1000 ohms from hand to hand when metal contacts are grasped, then it would require a pressure of some 500 volts to pass half an ampère, which by many is considered unnecessarily near the fatal current. When Mr. Tesla received his shocks at a pressure of

100,000 volts, the *quantity* of current communicated was small, and it is doubtful whether, in the majority of his experiments, it was as much as one-thousandth part of an ampère (one milliampère).

Again, to ensure fatal results, even with dangerous currents, *good* contact should be made, and the current should traverse vital parts of the body. Perhaps the absence of these conditions may account for the many instances of which every Electrical engineer knows, and which many have experienced, of shocks being received, which some few years ago were always understood to produce decidedly fatal results.

By concentrating the Electric shock under proper conditions on one or other of the vital organs of the body, it is, however, no difficult matter to instantaneously ensure a fatal result. Electrocution, scientifically carried out, is a most humane method of terminating the life that the law has condemned. Inasmuch as Electricity travels much quicker than the sensory nerves, the brain is naturally rendered insensitive, and the subject insensible by the rush of Electricity, long before the sensory nerves could communicate their impression of pain.

Friends of the gibbet are naturally loud in denouncing Electric executions, and the difficulty of resisting sentimentalism in this, as in other matters, is one of the great obstacles to any progress. After some two centuries of practice nothing more humane, however, seems to be attained than hanging a man, at the risk of pulling his head off, and if capital punishment must be enforced, it would surely seem that some method of instantaneous death by properly carried out Electrocution is worthy of adoption.

CHAPTER XVI.

ELECTRIC COOKING AND HEATING.

THE part Electricity will play in all great industrial enterprises is now fully recognised; but the changes it will inevitably bring about in the domestic household are still far from being sufficiently appreciated. This is largely due to the fact that Electrical Engineers have hitherto had their attention chiefly concentrated on providing a public supply of Electricity for lighting purposes, and until this work had been satisfactorily accomplished it was useless attempting further domestic applications of Electric science. So soon, however, as the many and difficult problems involved in the economical production and house-to-house distribution of Electricity were solved the commercial success of such undertakings was promptly shown to be dependent on a large and constant consumption of the current. Electric lighting, as a rule, is only required on an average for some four hours a day, and the earning capacity of a large central supply station capable of supplying Electricity in large quantities throughout the twenty-four hours is thus considerably limited. It was the demand thus made for new uses of the Electric current that has caused, especially in America, such a development in the use of small Electric motors for a variety of business and household purposes, and that has brought about the recent developments in Electric heating.

Every additional use to which Electricity can be put, increasing as it does the consumption of current, tends to improve the profitable nature of a Supply Company's undertaking, and in this way permits of Electricity being supplied at cheaper rates. The amount of Electricity consumed by a miniature motor for grinding coffee, working a boot-blacking machine, or even for a larger motor working the dinner lift occasionally, is very small indeed; but the general adoption of small Electric motors, Electric heaters, and other such useful household apparatus will help materially to reduce the cost at which Electricity can be profitably supplied for lighting purposes.

At the present charge for current for Electric lighting (averaging some 7d. per unit) the cost of Electric Cooking and Heating would be prohibitive; but the Supply Companies, anxious to obtain a sale for their current at times when otherwise their machinery would be standing idle, have already in some districts reduced the rates for cooking or heating services to as low as 3d. and 4d. per unit.

It is not, however, the novelty of an invention that constitutes its value so much as the fitness of its application, and in this respect Electricity as a means of heating and cooking undoubtedly has numerous advantages in favour of change and progress. Our methods, if always to be the fittest, cannot always continue the same; yet the operations of cooking are now in many respects what prevailed from times immemorial. Man yields to custom as he bows to fate; but the course of changing years has bettered many things in the past, and it would now seem as if our methods of cooking are likely to be revolutionised and improved by the same agency which has already wrought such changes in other directions.

Surely the need is great. "Heaven sends us good meat and the devil sends us cooks" does not represent the

dyspeptic cry of any one generation, but rather the judgment of all ages, and yet how often has the method as well as the master-hand been at fault. Scientific cookery hampered by unscientific ways is naturally ready and eager to avail itself of Electrical apparatus where cooking by accurate measurement is, if anything, easier than by the haphazard methods where gas or coal is employed.

It has been so often asserted that gas, if superseded as a means of lighting, will still find opportunities in heating and cooking of triumphing over its rival, that many have failed to appreciate how usefully Electricity can also be employed in the same directions.

Again, to many the very idea of Electric heating seems a paradox. Electricity has of late been chiefly associated in the public mind with lighting, and in this respect it has derived its principal advantage over gas from this very *absence* of heat. In the incandescent lamp, however, the light is caused by the carbon becoming *electrically heated* to incandescence, and Electric Lighting is thus only another application of the well-known heating effects of Electricity.

With Electric Light wiring, if the wires are too small, or if too much current is sent through them, they become heated and melt. In the same way coils of iron or platinum wire can be heated up by the Electric current and placed round any vessel, such as a saucepan. If, however, bare wires, through which Electricity is passing, are brought into contact with the metal of a saucepan, a "short circuit" or path for the current is made, and Electricity may be said to escape. With bare wires also the heat would be rapidly carried away by the cooler currents of air, and thus little of the actual heat would reach the saucepan. For these reasons the heating wires *are embedded in* some substance which shall conduct the

heat direct to the surface to be heated, and also act as an insulator for the Electric current. The heating-wires by this means are brought into close contact with the saucepan, or any other vessel to be heated without any of the Electricity escaping, while the heat in the wire is conducted rapidly to the surface to be heated.

The original method employed of thus separating the heating-wires from the metal surface to be heated was by means of mica or asbestos wrapped round the wires. Several forms of such apparatus were constructed, all of which were of little commercial value, as great difficulty was experienced in conveying the heat generated to the surface to be heated without great loss. Asbestos also did not entirely exclude the air from the heating-wires, and these consequently soon became destroyed.

In 1878, at the Crystal Palace Exhibition, Mr. Lane Fox made an improvement by embedding the wires in an insulating enamel, which also acted as a good conductor for the heat. His egg-boilers, coffee-pots, and curling-irons attracted then much attention. The enamel, however, cracked and would not stand such high temperatures, while the opportunities for the use of such apparatus at that time were not sufficient to induce inventors to give the subject more attention.

The recent demand for new uses to promote the consumption and sale of Electricity caused attention to be again directed to the subject of Electric heating apparatus. In 1891 various experiments resulted in the discovery of an improved insulating enamel which did not injuriously affect the substance of the heating-wires embedded in it, and which, by expanding and contracting equally with them, was able to withstand the high temperatures without cracking. As enamel requires to be burnt on, this method, although serviceable for iron griddles, heaters,

and ovens, was not equally suitable for copper or silver utensils, which often are affected in the enamelling process. However, this last difficulty has now also been overcome, as by a recent method the wires are embedded in an insulating cement, having the same properties as the enamel, but which can be applied in the cold state to the surface of any cooking or other apparatus. Both the enamel and cement processes are now employed.

The method by which the apparatus is fitted for Electric heating is most simple. A thin film of enamel or cement is spread over the saucepan or other vessel; iron, platinum, or other high resistance wire is laid zigzag over it, with copper wire connections made to the two ends, and finally more of the enamel or cement is spread over so as to completely embed the wires. When enamel is employed the apparatus is then put into a kiln, and the enamel burnt on similar to the ordinary iron cooking utensils. In both methods the film of enamel or cement insulating the heating-wires is so thin and so good a conductor of heat that the heat generated by the Electricity is rapidly conveyed to the utensil to be heated. More heating power, *i.e.*, Electricity, can thus be sent through the wires without fear of over-heating them than would be possible if they were exposed to the air, which does not conduct heat but simply radiates it.

The heat generated is proportional to the quantity of current used, and the amount of obstruction or resistance it meets with in its passage through the conducting wires. For this reason metal wires of high resistance are usually employed for such heating purposes, although non-metallic substances having the same qualities, such as carbon, may be used. The only limit to the heating effects is the melting-point of the wire, and although at first troubles were experienced through wires fusing, experimental tests

have since shown to what intensity the wires can be heated, without danger of their melting and destroying the Electrical connection.

GRIDDLE.

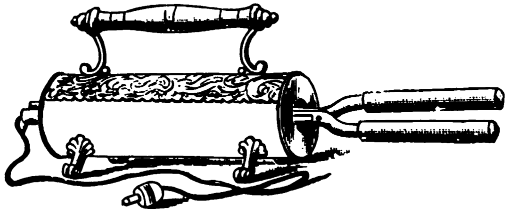
The illustration shows a form of griddle which is very convenient for frying eggs, pancakes, and a variety of such purposes; the uniformity of the heat prevents all

COFFEE-HEATER.

KETTLE.

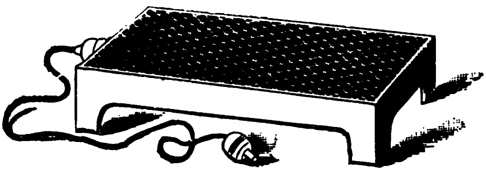
possibility of the articles sticking to the pan or unduly burning. It is only necessary to turn the current on for some two minutes before commencing to cook, and im-

mediately the cooking is finished the current can be switched off and waste prevented. In the Electric stew-pan two or three different circuits are arranged, so that in

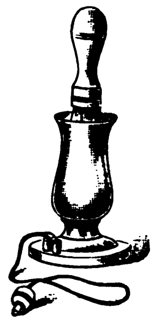


CURLING-IRONS.

the earlier process, when a considerable heat is required, all are switched on, while by turning off one or two switches any desirable degree of heat suited to the sim-



FOOT WARMER.



SHAVING POT.

mering process is secured. Heating effects can be very rapidly obtained, and the Electric curling-irons shown in ornamental nickel case will heat up to some 350 degrees

in two minutes. Coffee-pots, flat-irons, coffee-machines (see illustrations) and a variety of such household apparatus are now being manufactured ready to be connected up by flexible cords to the same Electric supply that furnishes the light.

Hitherto the saucepans, kettles, and other apparatus fitted for Electric heating have been of a similar shape to those previously used for other methods. Gas-heaters have already accustomed us to large flat-bottomed apparatus not previously employed, and the present forms of heating and cooking apparatus are not always the most suited for obtaining the best results by Electric heating. As there is no necessity to retain the present shapes, it is possible that the modification of them may result in a return to some of the old-fashioned forms of days gone by.

It will be remembered that in many of the old kettles a space was left in the centre (or in the case of an urn at the bottom), for a red-hot glowing piece of iron, and there seems no reason why an Electrically heated tube or spiral will not in the future be similarly employed to maintain the heat. Again, the possibilities of ornamenting Electric heating apparatus are infinite. Silver will no longer be the only luxury of which the afternoon tea-service is capable. As the heat is all inside, and anything may be affixed to the outer coating of the enamel, coffee-urns and tea-kettles may be covered with costly brocade or delicately hand-painted leather, and the heating process brought about by connecting up a silken flexible wire.

An illustration is also shown of an Electric radiator or warming stove fitted with three switches to allow of varying degrees of heat being obtained. The advantages claimed for these are that they maintain a steady, even heat, there is no dirt, smoke, or smell, while heat is soon given off after the Electricity is switched on.

In all such devices the high resistance iron or platinum wires play the same part that the filament does in the incandescent lamp, but instead of the substance being heated up to a glowing light, the heat is conducted through the surrounding cement and used in heating up different forms of apparatus. Some 150 patents for Electric heaters alone have been taken out in the United

RADIATOR.

States, as, owing to the intense cold these convenient and portable arrangements are extremely serviceable; for instance, in tramcars, which thus utilise the Electricity for heating and lighting as well as for traction. Now that attention is being devoted to the subject of Electric heating in this country, a very rapid development may *be expected* during the coming year. The warming of

halls and large buildings is already being experimentally tried, and bids fair to be successful where the Electric supply for heating can be obtained at special rates. Before long also many ornamental forms of heating apparatus may be expected, such as copper gongs, screens, and other novel heating devices, by which Electrical warmth will be conveniently obtained in any part of the room where it is desired.


CIGAR LIGHTER.

As a means of heating, Electricity is in this way not only most convenient and serviceable, but also offers advantages on the score of safety that are not possible in the use of coal, oil, or gas. All apparatus are fitted with safety-fuses, matches are dispensed with, and it cannot be too strongly emphasised that with Electric heating methods well carried out there is absolutely no danger from fire.

It is as well, perhaps, before leaving this part of the subject, to explain the methods on which Electric Cigar Lighters are constructed. A small piece of platinum suitably fixed at the end of a handle, is electrically heated to a white glow on pressing the switch connected with it. The Electric currents, however, that are usually supplied to a house for lighting purposes are considerably stronger than is necessary for heating

up this short length of wire. Additional resistance is therefore usually arranged for in a small ornamented case to which the Cigar Lighter is attached, so that the surplus Electricity may be absorbed, and the platinum wire prevented from fusing, as would otherwise be the case.

Electric Ovens.

The most important as well as the most interesting apparatus are naturally the Electric Ovens. As these are at present constructed they are fitted with five different circuits round the top and sides, each circuit being controlled by a separate switch. The inside plates of the ovens are all made radiating surfaces, and if less heat is required on one side or the other, that particular circuit can be switched off. Thus for heating, cooking, or baking, the whole of the heat is under control, and the temperature can be maintained uniform or varied at will. Although the present forms of gas-ovens have hitherto been used, tests and experiments show that modifications of the present apparatus would result in much improved heating effects being obtained.

It is very probable that much of the future cooking by Electricity may be done by means of circular coils of bare wire (made up in various forms and sizes somewhat like a kitchen cullender), and so arranged as to encircle the joint without coming into actual contact with it. The sides of the ovens in which joints thus surrounded by wire cooking cullenders are suspended would be formed of good radiating surfaces, and the heat retained in the ovens under the best possible conditions. There are, doubtless, certain difficulties connected with the use of such bare wire-heating apparatus, but these are capable of being overcome if the corresponding *advantages* are great. Indeed, a special cooking circuit

could be arranged for at a lower Electrical pressure than for the Electric Lighting, with a view of preventing any fusings, or slight shocks in handling the wires.

Cooking from the interior will also, undoubtedly, occupy a prominent part in the Electric cooking systems of the future. In the new methods of salting hams perforated needles are used, and the brine forced through them under pressure. For the Electric cooking process a similar arrangement may be devised. Electric skewers designed so that upon forcing them into the joint and switching the current on, a heat of any temperature can be given out at their points, should produce entirely different savours in the meats cooked by this means. Indeed, it requires a Brillat Savarin to do justice to a subject offering such immense gastronomic possibilities. The gourmet's jaded palate may truly be refreshed at the thought of a plover's egg cooked from the interior by a fine Electric skewer, while the epicurean, who has exhausted all known dishes, will have another world opened to him by these new culinary achievements.

Even in its present form, however, the Electric oven offers many advantages for cooking purposes. It is in every way as convenient as the gas cooking-oven, and far more cleanly. There need be no objectionable smell from carbonised fat, so often encountered where gas cookers are employed, and which is chiefly owing to the difficulty of keeping the iron surfaces free from grease and fat. The interior of the Electric oven may be bright and radiating throughout, recalling the shining surface of the Dutch oven of the past. The juice of the meat, also, in the gas cooker is often either dried up, or carried off with the products of combustion up the chimney, whereas in the Electrical method the food is rendered far more nutritious and savoury.

Some of the Electric ovens now made are ingeniously fitted with a mica window or door, and in this way, by means of an incandescent lamp inside, inspection of the cooking can be made at any time without loss of heat from frequent opening of the door.

The amount of heat in Electric ovens is capable of being automatically regulated by means of thermo-regulators, which cut off the current when the heat attains more than a certain temperature, and connect it on again when the temperature falls below the point at which the regulator is adjusted. A further development of this arrangement may be expected, by which the current can in the same way be switched off at the end of any given time, and cooking by Electricity carried out almost automatically. Thus the experimental work in the cooking schools of the future having shown that the best results in the cooking of certain viands are obtained when given amounts of current, producing certain known temperatures, are used for varying times, it becomes quite possible that Electric oven regulators may be adjusted so that the cooking process to a large extent completes itself.

The idea of cooking by a measuring meter, of course, is strange, but when losses of heat can be accurately calculated, when heat can also be applied for any stated time, and varied in any given way, the results can be exactly predicted. So far from making the process of cooking a complicated and scientific one, mathematical methods should simplify the directions of our cookery books, and the calculations taught in the board school will then become of service in the domestic kitchen.

Utopian as such ideas as these may at present seem, they contain nothing impossible, and, indeed, are but the aims of scientific cookery carried to their legitimate end.

Next, as to cost. Although cooking can be accom-

plished more conveniently, and as effectually, if not better, by Electricity than by gas or coal, the impression of its prohibitive cost is so widespread that even those who are interested in the processes often refuse to seriously regard it as a possible rival of other methods of food preparation. There is nothing that has helped to foster such ideas more than the considerable amount of Electricity required in the earlier forms of Electric kettles to boil water, and the cost of which was calculated at the lighting rate for current of 7d. per unit. As already pointed out, the Electric Supply Companies are now quoting prices for currents, when used for cooking and heating, as low as one-half of the rates they are charging for lighting, with a view to pushing the sale of their Electricity for such purposes. Every kind of cooking and heating can now be performed by Electricity, and the cost of the majority of operations compare favourably with that of coal, fire, gas, and other heating systems.

As to the actual cost of working the Electric heating processes, it has been proved theoretically that a Board of Trade Unit (see page 157), 1000 watts of Electricity (say 10 ampères at a pressure of 100 volts) will raise one pint of water from 60° Fahr. to 212° Fahr. (boiling point) in 3·3 minutes, and Electric copper kettles are made by which a pint of water can be boiled with the same amount of current in 3·7 minutes, thus establishing an efficiency of nearly 90 per cent. In the kettles which are generally sold, a pint of water is boiled with 300 watts (3 ampères at 100 volts), but taking of course a proportionately longer time, viz., some 12 minutes, and this amount of current at the rates charged of 3d. or 4d. *per hour* for 1000 watts (Board of Trade Unit) is equal to a cost approximately of ¼d.

Much of the heating and cooking usually required is of

an intermittent character, and when Electricity is obtained from a central supply station the process can be rapidly started, while immediately it is completed or the heat is no longer required, the current can be switched off, and there is an end to the cost. For short cooking operations a coal fire, on the other hand, is of but little use for the first half-hour, and when the work is done, much of the heat is lost in the expiring embers, where a waste still goes on.

It is only with gas that many of the small Electric heating operations can be compared, and who, for instance, would not prefer Electric curling-tongs, if only on the score of safety and cleanliness, to the gas method of heating? A well-known writer has said that the cost takes away the taste; but where does the cost come in, compared with the advantages of switching on from the bedside the coffee, milk, or water heater in the same way as one switches on the light? The greater cost of Electric lighting over gas has been no obstacle to its adoption, and when once the public mind is convinced of the workableness of these small Electric heating devices, the slight additional cost, if any, will not long be considered, compared with the many advantages gained.

The same considerations of cost apply to the larger operations of cooking by Electricity, if once it is recognised that meat can be more wholesomely cooked by the process.

To properly understand the cost of cooking by Electricity, it should be remembered that in an Electric oven there is no necessity for ventilation, and the oven may be entirely closed if need be. The amount of Electricity required to heat it up may be twice as much as the cost of gas or coal in the first instance, yet the cost of *maintaining this* heat is only one half. When an Electric

oven is heated to 400 degrees, the Electricity can thus be entirely switched off, as no heated air need escape up a chimney as with coal, or through a ventilation pipe as with gas. There are, of course, slight losses of heat through the walls of the oven, but by leaving on some 25 per cent. of the original current the full heat is kept up in the oven, and the cooking operation continued indefinitely at a very low cost for maintaining the heat. This is similar in some respects to the baker's oven, which, when heated early in the morning, has afterwards to work by means of the heat retained.

When coal is burnt in a kitchen range some 30 per cent. of the heat passes up the chimney or is lost through incomplete combustion, and some 64 per cent. is radiated in warming up the room, when the average difference of temperature between the stove and the room is taken at 80 degrees. Thus the efficiency of the cooking range is under 5 per cent. Professor Tyndall, in a test, is stated to have obtained the figure of 6 per cent., although another writer considers this the maximum, and puts the *all day* efficiency of the average kitchen grate at nearly 3 per cent.

No industry in the world has such a large proportion of competent manufacturers, and workmen who understand both the theory and practice of their work, as the Electrical industry. Surely, therefore, in this great fight for the most economical method of food preparation, it is possible to produce better results by Electric methods where the whole of the heat generated is utilised, and no loss occurs through radiation.

Undoubtedly far more heat can be obtained by burning coal in a kitchen grate than by using it in a boiler to drive a dynamo, and thus work an Electric heater from supply mains, but the waste of the former process is so

enormous, while in the Electric method the whole of the heat can be concentrated at those points only where it is needed. In Chapter XI. the many advantages of Electric motors worked from central supply stations were pointed out, and the same considerations apply to Electric heating apparatus. The production of heat in the form of Electricity takes place at the central station on a large scale. This is then available for use at all times in a variety of small, handy, and efficient Electrical apparatus, by which different heating, cooking, or other processes can be better and more economically performed than by the heat obtained from small grates and furnaces in each house.

The healthiest sign of the future of Electric heating and cooking may be said to be the constant correspondence in the technical journals as to tests and costs of the various processes.

It is hardly to be expected at the inception of such an enterprise that the most economical results can be immediately attained, but it has already been satisfactorily demonstrated that many processes of heating and cooking can be carried out as cheaply as with gas. The same statements of prohibitive cost were made when Electric lighting was first introduced, and now with incandescent lamps at 1s. 9d. and Electricity at 6d. per unit, Electric lighting can compete with gas with every prospect, as incandescent lamps become more efficient and the use of gas diminishes, of becoming within ten years cheaper than its rival.

It is no more a time now to cut off the supply from the gas cookers, or to turn out the kitchen ranges, than it was in 1879 to dispense with oil lamps, or gas illumination, because Edison had invented his system of Electric *lighting*. *But* Electric cooking will not have to wait so

long to become general as was the case with Electric lighting, since the current is already to hand, and the supply companies are willing to offer every inducement to use apparatus which shall be the means of increasing the daily consumption of Electricity.

All were not rich or fortunate enough to be able to afford Electric lighting when it was first brought out, and in the same way it will be some years before the many can experience the superiority of Electric cooking, but in the long run it will be the poorer classes who equally with the rich will find Electricity the most serviceable and convenient means both for the proper preparation of food and for a convenient supply of heat.

CHAPTER XVII.

ELECTRICAL ENGINEERING AS A CALLING—USEFUL TECHNICAL BOOKS AND GLOSSARY OF ELECTRICAL TERMS.

IN conclusion, it may be as well to refer to the prospects Electrical Engineering offers as a calling, more especially as, during the last two or three years, it has been regarded somewhat like the Church—as convenient for younger sons when nothing else offers. In these days of competition, when every profession and business is overcrowded, and the difficulty of starting in life very great, Electrical Engineering is naturally turned to as an unworked lode.

The impression often seems to be that any one has simply to determine to become an Electrical engineer, and forthwith that result is achieved. It is entirely forgotten or ignored that for Medicine or the Law a prolonged training is necessary, and even then some time elapses before a livelihood is earned.

In the first place, to be successful as an Electrical engineer one ought to have not only a good general ability, but also a natural liking for mechanics and science, and must have above all—brains. How seldom, however, is any natural inclination taken into account. Youths who have been for a time possibly in a tea warehouse where the prospects seem remote, or have failed in the preliminary examination for Law, are often pitchforked into Electrical

Engineering, without any regard whatever as to whether they are suited for it. Again, if a boy has bought a battery or two and put up an Electric bell, he is held to have indicated a "decided taste" for Electrical Engineering. These remarks are not made satirically, as the writer has unfortunately during the last three or four years had an unsought-for experience in the shape of shoals of applications for advice as to the best means to obtain an opening in the Electrical world for youths leaving school, or for others who have already tried other callings.

The "decided taste" alone is not sufficient to become an Electrical engineer properly so called. There is no calling which requires a more thorough course of training. To start with, one should become a good mechanic first, and this means a year or two spent as an apprentice or learner in some general engineering works. A premium is generally required, but if the firm chosen be a good one, the money is very well spent. In some of the large and widely-known engineering firms, so many pupils are usually taken that there can be no individual supervision, and the tendency is rather to play than to work. A small general engineering firm in the Midlands of good reputation, where there are two or three pupils only, offers greater advantages to a learner. The latter should get to the work at six in the morning with the other men, and have his time booked.

The knowledge and experience gained by such a training is never thrown away, and is serviceable whatever a man may take up in the future. It affords, too, a very good indication as to whether there is a desire to follow the line of life that has been chosen.

Having first laid a good groundwork, the superstructure consists, secondly, of technical work, and, thirdly, of practical Electric work. The second is really as necessary

as any other, but is often left out. Very often the time is grudged. At South Kensington the course is three years, and to a man who has already gained a good mechanical knowledge much of the class work and lectures seem to be unnecessarily prolonged on account of other students, younger and often inattentive. A good plan is to take up private reading or join some Electric engineering works, where besides the practical daily work, time can be spent in the laboratory, where the technical side of the subject can be studied.

If a training such as this be conscientiously carried out, there can be no doubt that by applying the ordinary rules of perseverance and industry, necessary in everything, a man will soon find himself in an excellent position, and ready to grasp the many opportunities which Electricity in the future is certain to present.

Although such advice may be given, how seldom it is followed!

As a rule, the desire to stay in London or the necessity of living at home, causes the suggestion of joining an engineering works to obtain the first requirement of all—a good mechanical experience—to be considered impossible and thus dispensed with. Sometimes when technical classes have been more or less diligently attended and an opening of some kind is sought, it is necessary to point out that, although something has been learned, much still remains before there is any chance of really succeeding.

It is pitiable to know the number of young men of all social conditions now seeking and begging for Electrical work. As a rule their training has been a two or three years' course at a technical college, where they have learned something which no doubt will be of advantage to them in the future, but who are not in any way qualified *for the work* they are seeking. It is necessary to point

out to them that even for the Electric wiring of houses a firm who have had any experience whatever would infinitely prefer men who originally were good mechanics, such as a skilled carpenter who, from a liking for the subject, has read Electrical books and acquired knowledge in one way or another. Such men make excellent foremen for wiring works, and much bad work has unwittingly been done by young men fresh from technical classes paying premiums of £100 a-year to Electrical firms, and who have been placed out as foremen on wiring works. For the other branch of Electric lighting work connected with engines, dynamos, and accumulators, a practical training is, of course, absolutely essential.

The leading men in the Electrical world are those who have distinguished themselves in other ways, and it may be mentioned that Drs. John and Edward Hopkinson were respectively Senior and Tenth Wranglers of their years. A good man can of course always make his way, whatever his training may originally have been. He will invariably get on and succeed in spite of all difficulties.

Apart, however, from the fact that the training of a man is often insufficient for the work he applies for, there is at present nothing like sufficient work for the enormous number who have drifted into Electrical engineering during the past four or five years through every conceivable channel. What is going to be the result cannot be foreseen, as, however rapid may be the progress of Electricity for light, power, and traction, it cannot for a long time absorb the number who are now, more or less, aimlessly taking it up as a livelihood. One thing is certain, that if a man wants to be in the running in the future, he must have a thorough training on the lines abovementioned. But it is too much to hope that these words of warning may prevent others from drifting into the

Electrical world, where their insufficient training and half-hearted interest must effectually debar them from achieving success.

Without pretending to give a list of the principal technical works on Electrical subjects, the following may be useful to those readers who desire to become acquainted with the more scientific aspects of the subjects dealt with in this book.

In any case, the Journal of the Institution of Electrical Engineers, published periodically (E. & F. N. Spon, London), price 2s. 6d. per number, will be found of the utmost value, as this contains the latest views of the leading Electricians on all important Electrical subjects. The weekly technical journals, viz.:—*The Electrician*, price 4d.; *The Electrical Review*, price 4d.; *The Electrical Engineer*, price 3d.; *Lightning*, price 2d., and also *Engineering*, price 6d., and *Industries*, price 6d., will always be found of interest. Books:—"Modern Views of Electricity," by Professor Oliver J. Lodge, London, Macmillan & Co., 6s. 6d.; "Electricity and Magnetism," by Silvanus P. Thompson, London, Macmillan & Co., 4s. 6d.; "Dynamo-Electric Machinery," by Sylvanus P. Thompson, London, E. & F. N. Spon, 12s. 6d.; "Electric Transmission of Energy," by Gisbert Kapp, London, Whitaker & Co., 7s. 6d.; "Short Lectures to Electric Artisans," by Dr. J. A. Fleming, London, E. & F. N. Spon, 4s.; "Electric Light Installations and the Management of Accumulators," by Sir David Solomons, London, Whitaker & Co., 6s.; "Electricity, its Theory, Sources, and Applications," by J. T. Sprague, London, E. & F. N. Spon, 15s.

GLOSSARY.

A.

Accumulators, or Secondary Cells, an apparatus for chemically storing electrical energy.

Acidometer, an instrument for measuring the specific gravity of acid.

Alternate Current Dynamo, a dynamo in which the current rapidly alternates or reverses its direction from positive to negative.

Ammeter, or Ampère-Meter, an instrument for measuring the current passing through a conductor.

Ampère, the unit by which the flow of current is measured—so called from Ampère, the French philosopher (b. 1755, d. 1836).

Ampère-hour, the current of one ampère flowing for one hour. When multiplied by the pressure in volts it gives the consumption of electrical energy in watt-hours, 1000 of which form the B.T.U. See **Watt-hour**.

Ampère-Meter. See **Ammeter**.

Arc, the Electric, the brilliant incandescence produced by the electric current flowing between two carbon points which are slightly separated.

Arc Lamp, a device for regulating and feeding the carbons of an electric arc, so that as the carbons consume the distance between them or the length of the arc is continually preserved.

Armature, that portion of a dynamo which revolves between the magnets and in which the electric currents are induced.

B.

Bare Conductors, Electric wires or conductors with no covering or insulation.

Batteries, Primary, a means of generating electric currents by chemical action.

Batteries, Secondary or Storage. See **Accumulators**.

Bitumen Insulation, a prepared bitumen compound used for covering or insulating electric conductors.

Board of Trade Unit (B.T.U.), a measurement of electrical energy decided upon by the Board of Trade for the public supply companies to base their charges upon. It is equal to 1000 watt-hours (see p. 157), or about the amount of electrical energy consumed by seventeen 16 candle-power lamps burning for one hour. See **Watt-hour**.

Brush of Dynamo, an arrangement of copper wires or gauze, for collecting the current from the commutator of a dynamo.

Buckling in Accumulators, a bending and displacement of the plates, caused usually by discharging the current too rapidly.

C.

Cables, Electric, usually applied to electric conductors consisting of stranded wires, to distinguish them from single wires.

Calibration, the standardising or correcting of any instrument to the standard value, such as a volt-meter, ammeter, &c.

Candle, The Jablochkoff. See **Jablochkoff.**

Candle, The Standard, a spermaceti wax candle burning 120 grains per hour, taken as the standard of reference for measuring the luminosity, or *candle-power*, of any light.

Carbonised Filament. See **Incandescent Lamp.**

Carbons for arc lamps, rods, or pencils, generally made from powdered gas coke hardened into shape by baking, and used for the electric arc.

Casing, Wood, a covering or sheath of wood, generally containing two grooves, used for the protection of insulated wires.

Cell, a box or other receptacle containing the elements and solutions necessary for the production or storage of electrical energy. A number of such cells are termed a battery.

Change-over Switch, a switch for changing electrical connections from one source of supply to another.

Charging, filling or storing an accumulator with electrical energy.

Circuit, a system of metallic or other conducting bodies placed in continuous contact and capable of conveying an electric current.

Commutator, bars of copper which form the ends of the armature coils, and from which the current is collected.

Conductivity, the facility offered to the passage of electric currents through a substance.

Conductor, a substance through which electricity will pass, but applied principally to those in which little resistance is offered to the passage of a current.

Continuous Current, a current from dynamo or battery which does not vary in direction and flows continuously. See **Alternate Current.**

Counter Shafting, intermediate shafting used to distribute power or to increase or decrease speed of machinery.

Current, Electric, the flow of electricity through any conductor.

"**Creeping,**" a leakage of electricity over the surface of an insulating body, caused by a film of moisture and dirt or deposit from evaporation forming a conductor.

Cut-out. See **Safety Fuse.**

D.

Dielectric, another term for insulator.

Distribution Board, a board from which branch wires or cables are led to various positions.

Double-pole Cut-out. See **Safety Fuse.**

Dynamo, a machine for producing electricity by transforming *mechanical* work into electrical energy.

E.

"**Earth,**" term employed to denote the leakage of electricity.

Earth Return, a circuit in which the ground or earth forms part of the conducting path. An earth return is usually formed by connecting the ends of an insulated line either to gas or water pipes, or to metal plates buried in the ground.

Ediswan Lamp, the incandescent lamp manufactured in this country by the Edison and Swan Company. See **Incandescent Lamp.**

Electric Arc. See **Arc.**

Electric-Motor, a machine similar to a dynamo, but used for converting electrical energy into mechanical power.

Electric Pressure. See **Electro-Motive Force** (E.M.F.).

Electrical Energy, the capacity of electricity for doing work, whether for electric lighting or for power or traction purposes. It is directly proportionate to the amount of current and its pressure. Thus by multiplying the flow of current in ampères by the pressure in volts the amount of electrical energy is obtained. See **Watt** and **Watt-hour.**

Electricity, Chemical, produced by means of chemical action.

Electricity, Frictional, produced by the frictional machine.

Electricity, Inductional, produced by the dynamo.

Electricity, Thermal, produced by the application of heat, as in the thermo-pile.

Electrodes, the two terminals forming the positive and negative poles in a battery.

Electrolier, a device for suspending a group of incandescent lamps; the equivalent of chandelier, gasalier.

Electrolysis, the process of chemically separating the component parts of any substance by means of electricity.

Electrolyte, any substance capable of undergoing a chemical dissolution by an electric current.

Electro-Magnet, a bar of soft iron temporarily magnetised by the influence of an electric current passing through an encircling wire.

Electro-Metallurgy, the science or process of electrically decomposing solutions or salts of metals.

Electro-Motive Force (generally written E. M. F.) is whatever produces the transfer of electricity, and therefore the force which supplies the pressure to an electric current. See **Volt.**

Electro-Plating, the depositing of metals by means of electricity upon the surface of another metal or other substance.

F.

Field, Magnetic, term used to express the space between the poles of a magnet through which the magnetic lines of force exist.

Filament of an Incandescent Lamp, the thread-like substance composed usually of vegetable matter (such as bamboo, cotton, paper, &c.), which by the application of intense heat has been carbonised. See **Incandescent Lamp.**

Flow and Return. See **Positive and Negative.**

"Forming" Plates, the operation of bringing the plates of accumulators into proper chemical condition.

Frictional Electricity. See **Electricity.**

Fuse. See **Safety Fuse.**

G.

Galvanic Electricity, produced by chemical action; so termed after Galvani (b. 1737, d. 1798).

Galvanometer, an instrument used in testing for showing the flow of an electric current.

H.

Horse-power, the unit by which the rate of doing work is measured. It is equal to the power expended in raising 33,000 lbs. one foot high in one minute.

Hydrometer, an instrument for measuring the density of liquids. See **Acidometer.**

I.

Incandescent Lamp, a glass bulb from which the air has been exhausted, containing a carbonised filament which becomes incandescent on the passage of an electric current.

Induced Current, electricity produced by the influence that one magnetic or electrified body has on another not in contact with it.

Induction, the influence that one magnetic or electrified body has over another.

Installation, the machinery, &c., necessary for producing the electric current.

Insulation, the non-conducting substance applied to the surface of an electrical conductor to prevent leakage.

Insulator, any non-conducting material, as gutta-percha, india-rubber, china, glass, &c.

J.

Jablochkoff, the inventor of the Jablochkoff Candle, an arrangement of carbons placed side by side, and separated by a suitable non-conducting substance, such as kaolin, and used to form an electric arc.

L.

Lamp, Arc. See **Arc Lamp.**

Lamp, Incandescent. See **Incandescent Lamp.**

Lamp, Sunbeam, an incandescent lamp of high candle-power.

Lamp-Holder, a holder or socket in connection with the electric circuit, into which an incandescent lamp is fitted.

M.

Magnet-Electro. See **Electro-Magnet.**

Mains, copper cables or other means used for the purpose of conveying *electricity,* chiefly applied to the larger conductors.

Measurement, Means of. See **Meter, Ammeter, Volt Meter.**

Megohm, a unit of resistance; equal to one million ohms. See **Ohm.**

Meter, Electric, an instrument for measuring the amount of electrical energy used.

Motive Power, any force which applied to a machine produces motion.

Motor, any machine which may be used for imparting mechanical power.

Motor, Electric. See **Electric-Motor.**

N.

Negative. See **Positive and Negative.**

Non-conductor, any substance which resists the passage of electricity, chiefly applied to those in which this quality is strongly marked.

O.

Ohm, the unit by which the resistance offered to the passage of an electric current is measured; the legal ohm is the resistance offered by a column of pure mercury, 106 centimetres in length and 1 millimetre in square section; from Dr. G. S. Ohm (b. 1781, d. 1854).

P.

Parallel Wiring, term used to express the system of electrical distribution, in which each lamp has its individual flow and return wires, no current passing through two lamps in series. See **Series.**

Permanent Magnet, a piece of steel or loadstone containing enduring magnetic force, and requiring no electric current to magnetise it as in the case of electro-magnets.

Photometer, an instrument for measuring the intensity of light.

Pilot Lamp, a test lamp frequently used in the engine-room to denote the E.M.F. of the current from the dynamo.

Plugs, Safety Fuse, the movable portion of the safety fuse, containing the fusible wire.

Plugs, Shoe, the movable portion of a shoe or wall attachment, to which are attached the flexible wires in connection with the portable lamp.

Poles, general term to express the positive and negative conductors in electricity, or the north and south extremities of a magnet.

Positive and Negative, terms used to distinguish the polarity of wires in an electric circuit; thus the flow is usually termed the positive pole, and the return the negative.

Potential, pressure, difference of potential is the electrical pressure between any two points, and is measured in volts. See **Electro-Motive Force,** see **Volt.**

Power, Transmission of, the operation of conveying or transmitting power from one point to another.

Pressure, Electrical. See **Electro-Motive Force.**

Pressure Meter. See **Volt Meter.**

Primary Batteries. See **Batteries.**

Primary Cables and Wires, in an electrical system of distribution where high-pressure current is transformed to low pressure all cables and devices conveying the high-pressure current are termed primary.

R.

Resistance, the opposition afforded by any substance to the passage of electricity. See **Ohm.**

Resistance Coil, a coil of wire offering a certain known resistance to the passage of a current.

Resistance, Measurement of. See **Ohm.**

Return Wire. See **Positive and Negative.**

Rheostat, an instrument consisting of one or more resistance coils for varying the resistance in an electrical circuit.

Rocker, an attachment on the bearing of a dynamo to permit of the adjusting of the brushes.

S.

Safety Fuse, or Cut-Out, a device for automatically stopping the flow of electricity in case of accidents or defects in the conductors; a single-pole safety-fuse controls only one wire, a double-pole controls both the positive and negative.

"Scaling" in Accumulators, the formation of a deposit upon the plates which prevents the acid from acting upon them.

Secondary Batteries. See **Accumulators.**

Secondary Wires, the low-pressure coils in a transformer, which are acted upon by the primary or high-pressure wires.

Series Wiring, a term used to express the system of wiring in which the same current travels through two or more lamps before completing its circuit. See **Parallel.**

Shoe and Plug. See **Wall Socket.**

Short-Circuit, term used to express any metallic or other connection formed accidentally between a positive and negative wire, by which the current may take a short cut, instead of completing its journey through the lamp, motor, &c.

Sunbeam Lamps, incandescent lamps of high candle-power.

Switch, an arrangement for breaking or completing an electric circuit.

T.

Telpherage, a system of overhead transportation by means of cars running on two steel rails, from which an electric current is obtained to work motors fixed on one or more of the cars.

Tension, pressure. See **Electro-Motive Force.**

Terminal, *attachment* screw, generally in the form of an, by which a *current enters* or leaves any electrical apparatus or conductor.

Three-Wire System, a system of distribution, in which the dynamos and conductors are connected up, so that one conductor answers as a flow and return to two dynamos, and by which a considerable saving in the cost of the conducting cables is effected.

Transformer, an instrument for reducing or transforming a high pressure current to a low one by induction.

Transmission of Power. See **Power.**

Two or Three-way Switch, a switch having two or three contact pieces attached to conductors, which by means of a movable handle permit the current to be sent into either conductor.

Thermo-pile, a combination of certain metals coupled together so as to produce Electricity by the application of heat.

Turbine, a machine for utilising the force or fall of running water.

U.

Unit, Board of Trade. See **Board of Trade Unit.**

Unit of Electrical Energy. See **Watt.**

Unit of Current. See **Ampère.**

Unit of Pressure. See **Volt.**

Unit of Resistance. See **Ohm.**

V.

Volt, the unit by which the electro-motive force or pressure of current is measured. It is the E.M.F. that will cause a current of one ampère to flow against a resistance of one ohm; from Volta, the Italian scientist (b. 1745, d. 1826).

Volt Meter, the instrument for measuring the pressure or E.M.F. of a current.

Vulcanised India-rubber, india-rubber, treated with sulphur, &c., to preserve and make it hard.

W.

Wall Socket, or Shoe and Plug, an arrangement permitting the instant attachment or detachment of a portable electric lamp.

Watt, The, the unit by which electrical work (or in other words, the electrical energy consumed) is measured. It is equal to the current of one ampère flowing at a pressure of one volt. See **Watt-hour.**

Watt-hour, term used to indicate the consumption of electrical energy of one watt in one hour. By multiplying the current in ampères by the pressure in volts, and again by the hours in use, the amount of electrical energy consumed is obtained in watt hours. 1000 watt hours equal the Board of Trade Unit (B.T.U.).

Wire, Flexible, a conductor composed of a large number of fine wires stranded together, so making it flexible.

Wires, Electric, small conductors, other than the mains.

Wood-casing. See **Casing.**

EXTRACTS

(by permission)

FROM THE

PHŒNIX FIRE OFFICE RULES

FOR

ELECTRIC LIGHT INSTALLATIONS.

Conductors.

Accessibility.

RULE No. 1. Where practicable, all conductors in a building should be so placed as to be easily accessible, and capable of being thoroughly inspected whenever required.

It is desirable, therefore, that conductors be not run out of sight, such as between floors and ceilings, under roofs, behind skirting-boards, wainscoting, &c , if it can be avoided.

Sectional Areas.

No. 2. All conductors to have sufficient sectional area, so as to allow at least 100 per cent. more electricity being safely sent through them than will ever possibly be required for the lights they are to supply.

By safety is meant that there shall be no perceptible heating of the conductors to the touch: and when proportioning their sizes, the possibility of their sectional areas getting diminished by corrosion or mechanical injury, as time goes on, should never be forgotten; the importance of this cannot be overrated.

Under normal conditions for internal work, the quantity of current sent down a conductor must not exceed the ratio of 1000 ampères per sectional square inch of copper, when the amount passing through the said conductor does not exceed 100 ampères : should the amount of current exceed 100 ampères, the ratio of course must be less.

It is as well to arrange the work when it can conveniently be done so that not more than 100 ampères pass down any single conductor.

The conductors should be of copper, the conductivity of which should not be below 98 per cent. of that of pure copper. The use of copper, however, is not obligatory in all cases.

When insulated copper is used the copper should be "tinned" or otherwise protected from the possibility of any injurious action upon it from the *insulation.*

All conductors of a larger sectional area than No. 16 S. W. G. should be composed of strands. No conductor of less size than No. 18 S. W. G. should be used except in fittings, and in fittings no conductor should be less than No. 20 S. W. G.

No. 3. No naked conductor, or conductors, allowed in a building.

Unless in those cases in which special permission has been obtained to the contrary.

Insulation.

No. 4. All conductors (except those for certain special risks) must be highly insulated with substantial coats of india-rubber of the highest quality, and which *must be specially prepared to last*, and which must be of approved thicknesses (or other *specially approved* equally good material or materials that will not too readily become plastic, that are impervious to moisture, and of lasting quality, and to use which special permission has been obtained). With regard to the coats of india-rubber, the outer one must be vulcanised (or treated in other specially approved manner), but the one next the metallic conductor must be pure, unless permission to the contrary be given, and the insulation should be protected by strong and durable coverings such as braided hemp, and the like, which should also be impervious to moisture. The insulation should be as uninflammable as practicable, regard of course being had that neither its efficacy nor its durability is in any way diminished thereby, and must contain no ingredient that would injuriously affect the metallic conductor it insulates, unless efficient safeguards have been taken to protect the metallic conductor from any possibility of such injury.

The insulation on a conductor must be in the form of a homogeneous tube.

No material or materials will be allowed to be used under any circumstances for the purpose of insulation, except those that are approved by the Technical Officer of the Fire Office. The composition, quality, thickness, and resistance of the insulation of all conductors must be to his entire satisfaction.

Nothing is stated above as to the resistance required in the insulation of conductors before being placed up in a building. So many cases having occurred of insulation that has given extremely high results so far as tests are concerned before being placed up, breaking down after having been in use for a short time. What is really required is, an insulation that will last, even though its resistance may not have been originally so very high. It may be mentioned, however, that the insulation resistance of conductors before being placed up should not be less than 250 Meg-ohms per mile in

dry places and 600 Meg-ohms per mile in damp places. The test must be taken with an electro-motive force of not less than 400 volts after the cables have been immersed in water at 60 degrees Fahr. for 24 hours, and with one minute's electrification.

Casing and Arrangement.

No. 5. In non-hazardous risks, the conductors having been thoroughly well insulated, as described under Rule 4, should be enclosed in substantial wood casing; and the conductors kept apart by a continuous fillet or width of wood, and the fillet or width of wood should be 1½ inches in breadth in the case of mains, 1 inch in breadth in that of the principal branches, and ½ inch in breadth in that of the smallest branches. The casing should be composed of sound, hard, well-seasoned wood. Iron or other approved metal tubes may be used instead of wood casing, unless in the opinion of the Technical Officer of the Fire Office metal tubing would not be desirable. In those instances where special permission has been obtained to run conductors unencased, the mains then should be kept at least from 4 to 6 inches, and the small branches at least 2 inches apart; and no conductor should be less than 2 inches from any other conductor, or conducting substance, unless special precautions against contact have been taken. Where external injury is possible, the conductors must be enclosed in hard-wood casings, or slate or other approved casings, or laid in cement troughing (dry), or securely placed in iron or other approved metal tubes (except under those circumstances where the use of metal tubing would not be desirable), or otherwise efficiently protected.

Where permission has been given for conductors not to be enclosed, and when the electro-motive force exceeds 220 volts with a continuous current, or 110 volts with an alternating current, the distance the conductors should be kept apart from each other, and from all other conducting substance ought to be at least 6 inches, unless permission for a lesser distance be given.

In hazardous risks, all conductors should be further protected. Having been thoroughly well insulated as before described, they might be laid in sound, hard, well-seasoned wood casing treated with an approved fireproof paint or compound, and packed in with asbestos or silicate cotton or other approved material; or they might be laid in cement troughing, or where applicable in separate earthenware tubes (or separate iron or other approved metal tubes may be used when alternating currents are not employed).

For theatres and very hazardous risks, see Rule No. 36.

In all risks, if the electro-motive force exceeds 220 volts with a *continuous current,* or 110 volts with an alternating one, special

precautions, varying according to the electro-motive force employed and the surrounding conditions, may be required.

Where the current is of extremely high electro-motive force, then the conductors may have to be encased and kept apart as described in Rule No. 29, for the primary conductors carrying alternating currents to secondary generators, or be arranged in such special manner as may be decided, having regard to all the circumstances of the case and the risk.

There must be no "bunching" of positive conductors together or of negative conductors together in a building, without permission.

There must be no crossing of wires in casing.

When alternating currents are used, conductors should not, without permission, be laid in metal tubes. (This does not refer to the wiring of Electroliers.)

It is preferable that all wood casing in non-hazardous risks be treated with an approved fire-proof paint or compound, in order to render it as non-inflammable as possible.

The covers of the wood casing should be screwed on; they should be screwed at the sides. The covers for large casings should be screwed at the centre as well as at the sides.

It is sometimes desirable to putty the joints of wood casing.

Conductors must never be laid in cement whilst it is wet, nor while it is drying, when there is any liability of the insulation being injured thereby.

Care must be taken to ensure that any cement or putty that may be used, contains no oil or other ingredient that would be injurious to the insulation of the conductors, or would in any way cause the insulation resistance to be lowered.

When lamps are in series, the minimum distance apart of any two conductors (or portions of the circuit), must be regulated by the difference of potential between such conductors (or portions of the circuit).

The small conductors about lamp fittings cannot always comply with Rule No. 5. The work, however, in connection with them, must be of a thoroughly secure character.

The best rule to follow when laying the conductors, is to so arrange them, that they will still be practically insulated, in the event of their insulating coverings getting worn away, or removed.

Twin.

No. 6. Twin wires are allowed only in those circumstances in which permission is given. They should be kept as free as possible from the vicinity of inflammable materials, be very carefully protected by cut-outs, their insulation should be as substantial as possible, and protected also as much as possible against abrasion; the wires should not be in positions where they could make an earth. *Too much attention cannot be bestowed to this rule.*

All twin wires, and the positions in which they are placed, must be to the satisfaction of the Technical Officer of the Fire Office.

Frequent examination of twin wires should be made.

No. 7. All conductors in buildings passing between floors and ceilings, under roofs, behind wainscoting, through partitions, or otherwise out of sight, must, unless special permission to the contrary has been obtained, be enclosed in wood or earthenware casing, or laid in cement troughing, or in separate earthenware tubes, or in approved metal tubes, in the manner described under Rule No. 5.

Hidden.

No conductor carrying an alternating current of over 110 volts, nor any conductor carrying an alternating current that forms part of a Three Wire System, the electro-motive force of which, between the first and third conductors, exceeds 210 volts, to be laid out of sight, such as between floors and ceilings, behind wainscoting, &c.

In ordinary risks, wood casing may be used when conductors pass between floors and ceilings, &c., except under those circumstances when, in the opinion of the Technical Officer of the Fire Office, wood casing would not be desirable.

No. 8. All conductors in a building that are exposed to moisture, must have thoroughly waterproof insulation, and special care to protect the conductors from damp must be taken. All casings, under similar conditions, in or about a building must also be thoroughly waterproof, and of lasting material and character. Too much care cannot be taken with regard to these matters.

Exposed to Moisture or Damp.

When conductors are being placed in buildings during course of construction, or before the buildings are "dry," the utmost care should be taken to guard against injury to the insulation, joints, fastenings, switches, casings, &c., from the action of any damp material or materials; from neglect of these precautions much trouble has arisen in installations. An electrical contractor should never be required to place work in a building if it be not sufficiently "dry."

Wood casing under roofs should be specially protected against moisture.

No. 9. External conductors attached to a building must, unless permission to the contrary be given, be insulated, and the insulation must be of a waterproof and durable character calculated to resist deterioration from atmospheric influences.

External and Overhead.

The insulation, method of fixing, general arrangement, &c., to be to the satisfaction of the Technical Officer of the Fire Office.

Conductors passing over a building come under this Rule.

No. 10. Conductors must never pass through party walls separating two risks, unless permission to do so has been given; and when this has been obtained, provision must be made, so that the conductors cannot be a means whereby fire can be communicated from one risk to the other.

Passing through Party Walls.

If conductors are carried up lifts, special precautions may in some cases be required.

Passing up Lifts.

No. 11. All conductors passing through the exterior walls of buildings must be insulated and enclosed in separate earthenware or approved metal tubes, or laid in a cement not injurious to the insulation, in the manner described under Rule No. 5.

Passing through Exterior Walls.

The arrangement must be such as not only to prevent moisture entering, but also fire penetrating from the outside by running along the conductors.

Conductors should never enter a building through the roof without special permission.

Joints.

No. 12. When two conductors are joined together, the junction must be soldered. All joints must be most carefully made and insulated, and under no circumstances must the sectional area of the conductors be reduced. The insulation of joints must be as perfect as possible, of a lasting character, and waterproof; special care must be taken to guard against moisture in damp places.

Resin should be used when soldering.

The surface of a joint should be smooth after soldering, and have no projecting points that might tend to pierce the insulation.

Cut-Outs.

No. 13. Wherever a branch is led off any conductor to supply current for one or more incandescent lamps, or for any other purpose, a short length of lead, tin, or other fusible metal or substance, must be inserted at the junction of the branch with the conductor, or as close thereto as possible; and the lead, tin, or other fusible metal or substance, must be of such section, length, and nature, that if the current passing through it exceeds the normal current by 50 per cent., then it will fuse and disconnect the branch. In those circumstances where it is conveniently practicable to have cut-outs that will fuse at a less excess above the normal than 50 per cent., these must be placed in. All cut-outs should be proportioned to fuse at as small an excess above the normal as is compatible with the proper and efficient *working of* the lights.

Cut-Outs (Branches).

When the normal current sent down a small wire does not reach half of the safe-carrying capacity (as described in Rule No. 2) of the said branch, then the cut-outs may be arranged to fuse at a higher percentage than that stated in the above paragraph. Provided such amount of current does not exceed 100 per cent. of the normal current of the small wire; and that the margin of safety is not lessened thereby. All principal branches, and branches having a considerable number of lights, must have cut-outs on both poles. Small branches, taken off conductors of much larger size, and the branches supplying current to fittings containing several lights should have cut-outs on both poles.

When the current is derived from a central station, or from accumulators, no branch carrying four ampères or upwards should be without cut-outs on both poles.

Cut-Outs (Precautions).

All "cut-outs," including the materials of which they are composed, and the positions in which they are placed, must meet the approval of the Technical Officer of the Fire Office; many cases having occurred of "cut-outs" failing to act when required, and even, sometimes, themselves being the cause of a fire. They should never be placed under floors, inside roofs, or behind wainscoting or skirting-boards, or in wood cupboards, &c., unless special precautions are taken, and *special* permission obtained. They must be so arranged and mounted, that no danger could arise in the event of their heating or fusing.

Cut-Outs (Definition of Branch).

By "branch" is meant any conductor issuing from another of greater sectional area.

If any conductor, by reuniting with any other conductor, or by any other arrangement, becomes technically part of the main or otherwise, it will still be considered as a branch if its sectional area is less than the conductor it issues from, and must be protected as such.

Cut-Outs (Mains).

The mains themselves, both positive and negative, must be protected by cut-outs, which should be placed as near the dynamo (or source of electricity) as possible; these, like the other cut-outs, must be proportioned to fuse at as small an excess above the normal as is practical and compatible with the efficient working of the installation. The excess above the normal must not exceed 50 per cent. without permission.

Cut-Outs (General).

If, however, a branch is already protected by "cut-outs" on the mains, or on a superior branch, then it may not be necessary to again protect it by other "cut-outs," unless required to do by the Technical Officer of the Fire Office.

The Technical Officer of the Fire Office may give permission, under certain circumstances, for a larger proportion of current than 50 per cent. above the normal to be carried by a cut-out.

When lights are grouped, as upon electroliers, &c., the small wires to each light cannot always have "cut-outs." Care should be taken, however, that the last controlling "cut-out" carries as small an amount of current as practicable, and that it will act before the smallest wire runs any risk of getting unduly heated.

When an incandescent installation is arranged on the "multiple circuit" system with distributing switch and cut-out boards, the ultimate distributing circuits should carry as small an amount of current as possible—not more than from 4 to 5 ampères, and be protected by "cut-outs" on both poles.

Cut-Outs (Arc Circuits).

With regard to arc circuits, or when incandescent lamps are arranged in series, the question as to whether fusible "cut-outs," or what other kind of "cut-outs" should or should not be used, will be decided as each particular case arises; so much depending upon the arrangement of the lights and the system of lighting.

Cut-Outs (Magnetic).

Should it be desired to use magnetic "cut-outs," or any other kind of "cut-outs," in lieu of fusible ones, permission must first be obtained.

Fastenings.

No. 14. The fastenings of conductors should be composed of a non-conducting material. When conductors are not encased they should, where practicable, be fastened to porcelain or earthenware insulators. Where, however, metal staples are used, a piece of india-rubber, or other approved insulating material, should be inserted between the head of the staple and the insulation of the conductor. Staples, however, ought never to be used, saddles or wood cleats being preferable.

In the case of external conductors, the fastenings ought always to be composed of a non-conducting material.

Earth Return.

No. 15. No earth return allowed.

Unless in those cases where special permission to the contrary has been given.

Switches.

No. 16. The house mains must have switches on both poles, and the same arrangement should be carried out as well on all the principal branches when the current is supplied from a central station or from accumulators. The arrangement should be such that the current can be entirely cut off from the lights in any portion of the building the occupier may desire.

It should never be forgotten that turning off a single switch, although it puts out the lights, does not turn off the electricity, which is still on, and which, under certain circumstances, may break out and fire the place. All the principal portions of a building, therefore, should be controlled by double switches.

All switches to be of such construction and make that they will not be liable after short use to get out of order and heat or fire. Their construction should also be such, that it would be impossible for them to remain in any intermediate position between full on and off.

All switches must be mounted and placed in such a secure manner that no danger can arise in the event of their heating. They must also be so mounted, that leakage of electricity from them is rendered impossible. Their rubbing surfaces should be large.

Switches inside buildings, for instance, must always have an incombustible base, the insulation of which should be perfect; no metal-work carrying current should be exposed at the under side of the base; the cover should be incombustible, and they should be kept perfectly free from moisture; the fastening screws should not come into contact with the wall, but be separately fixed into an insulating block.

With regard to switches contained in the sockets of lamps ("key sockets"), these will be allowed in those places and under those circumstances only for which permission has been obtained from the Technical Officer of the Fire Office.

Where practicable every room and every passage should be controlled by a separate switch.

The last controlling switch should carry as small an amount of current as is conveniently practicable. The current carried by it should not, except under special circumstances, exceed six ampères.

No. 17. A switch on each conductor and a cut-out on each conductor should be placed outside a building at or near the entrance of the conductors, when the electricity is generated externally.

When switches and cut-outs cannot satisfactorily be placed outside a building, they must be fixed inside at the entrance of the conductors into the building; and the conductors for this purpose must be brought into the building in as perfectly secure a manner as possible to a suitable place for fixing up these switches and cut-outs in thoroughly secure and accessible positions.

When a building is in the occupancy of various tenants, each tenant must have a double switch and double cut-outs immediately *at the points* of entrance of the conductors into his tenancy (pre-

ferably on the outside). The conductors should be brought in in a perfectly secure manner for the safe placing up of the switches and cut-outs.

A cellar may be considered as a building or part of a building from a fire point of view, unless there are circumstances that do not warrant this in the opinion of the Technical Officer of the Fire Office.

When the source of supply is internal, then a switch and a cut-out should be placed on each conductor in the dynamo-room.

Switch-Boards.

Switch-Boards. No. 18. Switch-boards should be composed of a non-conducting fireproof material. They should be in a dry and secure place and most carefully fixed and mounted, and the arrangement of the conductors at the back should, where possible, be such, that if on fire, the fire could not spread to the rest of the installation.

It is preferable for switch-boards to be "split," *i.e.*, the positive portion separated from the negative part.

All switch-boards should have an Oak, Teak, or Mahogany frame with glass front.

Connections. Resistances. Lamps.

No. 19. All resistances, bare or other connections, lamps, &c., must be mounted and placed so securely that no danger could arise in the event of their heating. They must be so mounted that leakage of electricity from them is impossible. All connections must be as perfect as possible. Resistances must be securely mounted upon an approved incombustible material, and kept well away from inflammable materials.

Incandescent Lamps.

No. 20. All inflammable materials must be kept at a perfectly safe distance from incandescent lamps. Incandescent lamps may sometimes get exceedingly hot, and be the means of causing a fire to break out.

Arc Lights.

No. 21. No naked lights allowed. If Arc Lights are used, they must be furnished with globes which must be enclosed at the base, and so arranged at the top that no sparks or flame can escape. The globes must be covered round with wire netting. When Arc Lights are run in series, means must be taken for maintaining the constancy of the current, whatever number of lamps may be burning.

Lamp-Holders, Ceiling-Roses, and Wall-Sockets.

Lamp-Holders. No. 22. All lamp-holders must be incombustible, and of an approved type. It is preferable to solder the ends of flexible wires, when composed of fine strands, before attaching them to the holders.

Ceiling-Roses. All ceiling-roses must be of an approved kind, and should be composed of an approved incombustible material and be most carefully made and fixed. Their construction should be such that no strain can be thrown on the pendant wires at their terminals in the ceiling-roses. They should be fastened to back blocks.

Wall-Sockets. No wall-sockets with flexible conductors will be allowed in any place or in any risk that the Technical Officer of the Fire Office may consider to be undesirable. All wall-sockets must be of an approved kind and composed of an approved incombustible material, and the greatest care must be exercised in fixing them. The flexible conductors should be most substantially insulated and the insulation well protected against injury.

Electroliers.

No. 23. Electroliers should be fastened to an insulating block, which should be separately fixed to the wall or ceiling. The wiring should be of a most secure and lasting character, and carefully arranged so that it would not be liable to mechanical injury. Each electrolier should be protected by cut-outs.

Gas Fittings and Electric Light.

No. 24. Gas fittings and Electric Light work should be kept quite distinct from each other.

Gas fittings should never be used for the Electric Light unless permission to do so has first been obtained. The Gas fittings would then have to be made thoroughly suitable for the purpose, and so arranged that it would be impossible for them to be the means of an "earth" being set up.

The utilisation of Gas fittings for the Electric Light may be the cause of the entire installation breaking down.

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